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THE FAUNA OF THE PITKIN FORMATION OF ARKANSAS[1]

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ABSTRACT.—The Pitkin formation is a thick, predominantly limestone sequence of strata in northern Arkansas characterized by a unique and isolated fauna probably of Clore and younger age. The fauna is briefly discussed, a faunal list is given, and new species are described as follows: 4 corals, 1 blastoid, 1 stelleroid, 11 bryozoans, 4 brachiopods, 4 gastropods, and 1 cephalopod. At present 208 species are known from the Pitkin.

INTRODUCTION

THE IDENTITY of the Pitkin formation of Arkansas was first recognized by D. D. Owen, who termed it the "Archimedes limestone," but it was named the "Pitkin limestone" by E. O. Ulrich in 1904 from exposures presumably near the town of Pitkin (now called Woolsey), but no precise type locality was specified. Actually, the Brentwood limestone member of the Bloyd shale (Morrow Group) is the most conspicuous unit cropping out at Pitkin and it is probable that the type locality of the Pitkin formation is at the conspicuous bluff along highway 71 three-quarters of a mile southeast of the town of West Fork, Arkansas, in the W½, NW¼ sec. 4, T. 14 N., R. 30 W. Although commonly described as a limestone, the Pitkin has been shown (Easton, 1942) to include a considerable proportion of shale and some lenticular sandstone bodies.

The Pitkin formation extends from near Muskogee, Oklahoma, where it occurs in scattered outcrops, to the vicinity of Batesville, Arkansas. It crops out continuously across the north escarpment of the Boston Mountains, with the thickness varying from about 20 feet in western Arkansas to a possible maximum over 400 feet in Searcy County. Farther east it thins to where the Boston Mountains terminate at the Mississippi Embayment and the formation is no longer fully exposed. There is also thickening from the north, where the formation is partly conglomeratic, to the south. The northern shore of the Pitkin sea probably lay not far north of the present northern limit of outcrop.

Most strata within the Pitkin are locally very fossiliferous, the upper portions being the most fossiliferous of all. Snider (1915) was the first to describe species from this formation and Girty (1929) and Laudon (1941) subsequently have added new species. The fauna has either been examined or referred to by Croneis, C. A. Moore, Purdue and Miser, Roth, Sutton, and Ulrich.

Because the Pitkin is the youngest Chester formation in Arkansas, it is important that its fauna be well understood in order to deal competently with the problem of the Mississippian-Pennsylvanian boundary. In northwestern Arkansas the Pitkin typically

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is overlain by the Hale sandstone and underlain by the Fayetteville shale but eastward from Newton County the contact between the Pitkin and the Morrow strata is exceedingly difficult to recognize, therefore, this paper is chiefly concerned with the Pitkin fauna of the western area.

ACKNOWLEDGEMENTS

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FAUNAL RELATIONS AND CORRELATIONS

The late Chester age of the Pitkin formation is well established by a comparison of its fauna with the Chester faunas of Illinois. The upper Chester is characterized in part by the presence of *Composita subquadrata*, *Eumetria costata*, *Buxtonia arkansana?*, and *Glyptopleura inoptina*, to mention only those species which occur in both the upper Chester of Illinois and in the Pitkin. The Pitkin fauna, however, is composed not only of typical upper Chester species, but also of some species characteristic of overlying Pennsylvanian beds and others that are typical of strata older than the upper Chester. As in the Chester faunas of Illinois, there are many species that have a long Chester record. The chief faunal characteristics of the Menard, Clore, and Kinkaid limestones of Illinois, as indicated by Stuart Weller (1920) are given below.

In the Menard limestone occur *Pentremites fohsi*, *Pterotocrinus menardensis*, abundant spinose summit plates of *Hydreionocrinus*, *Archaeocidaris* plates, and a large coarse form of *Spirifer increbescens*. *Composita subquadrata* replaces the earlier Chester *Composita trinuclea* in this formation and *Eumetria costata* replaces the earlier *Eumetria vera*. *Sulcatopinna missouriensis* is most common in the Menard.

The Pitkin formation contains *Pentremites*, *Pterotocrinus*, *Hydreionocrinus*, and *Archaeocidaris*, but these elements are not of great value unless known specifically. *Spirifer increbescens* and *Sulcatopinna missouriensis* are apparently lacking, but *Composita subquadrata* and *Eumetria costata* are both present

In the Clore limestone *Composita subquadrata* and *Spirifer increbescens* are associated with *Buxtonia arkansana?*. *Batostomella nitidula* is a conspicuous element and is locally very abundant, whereas *Glyptopleura inoptina* is known in Illinois only from the Clore. *Rhombopora* is common.

The presence in the Pitkin of *Buxtonia arkansana*, *Composita subquadrata*, *Glyptopleura inoptina* (of which more later), and species of *Batostomella* and *Rhombopora* indicate more similarity between the Clore and Pitkin than between the Menard and Pitkin.

The fauna of the Kinkaid is characterized by the return of *Composita trinuclea*, which is associated with *Martinia contracta* and *Sulcatopinna missouriensis*.

The Pitkin contains *Composita trinuclea*, *Martinia*, and also *Composita subquadrata*, the last of which is not known from the Kinkaid. This unusual circumstance, the recurrence of *Composita trinuclea*, is shared by both the Kinkaid and Pitkin, but the occurrence of *Composita subquadrata* must be explained at present as a holdover in the Pitkin.

Glyptopleura inoptina, the types of which were collected about 20 feet above the base of the Fayetteville shale, has been found in Illinois only in the Clore, according to C. L. Cooper (1941, p. 11). The species also occurs near the base of the Pitkin in western Arkansas (which is well up in the total aggregate of the formation), therefore, several hundred feet of strata occur between the Fayetteville and Pitkin occurrences. The correlation of the Clore with either the Pitkin of western Arkansas or part of the lower portion of the Fayetteville shale is indicated, in either of which cases, the Pitkin must be very late Chester.

Several Pitkin elements are of decided Pennsylvanian aspect. *Eoasianites* n. sp. is very similar to *E. oblatus* from the Morrow

of Arkansas and may be ancestral to the latter, as A. K. Miller has indicated that the Pitkin species is the more primitive.[2] *Euphemites* n. sp., though known from other Chester beds, is widely present in the Pennsylvanian. *Hemizyga* is typically found in the Upper Carboniferous. *Delocrinus* is typically Upper Carboniferous, and Laudon (1941, p. 384) has already mentioned the Upper Carboniferous aspect of the Pitkin crinoids, all but one of which are Inadunata. *Pleurodictyum eugenei* has heretofore been thought to have been restricted to the Pennsylvanian. *Dielasma arkansanum* and *Eumetria vera* are known from Mississippian and Pennsylvanian beds. Altogether, 64 genera, or half of the 130 recognized genera represented in the Pitkin fauna are known to occur in Pennsylvanian strata; this would indicate a late Chester age for the Pitkin formation, although it is inconclusive proof.

Several elements of the Pitkin fauna are typical of much older strata. *Syringothyris* n. sp. represents a genus characteristic of rocks of Kinderhook through Keokuk age. In the Mississippian, *Pustula* and *Krotavia* were known only from the Kinderhook to Burlington and from Kinderhook strata, respectively, although a Pennsylvanian species of each has been described. *Aganaster* is typical of part of the Borden group. *Amplexus* has a long range from Devonian to Pennsylvanian, but is most characteristic of the Lower Mississippian or Iowan series. *Holopea newtonensis*, if it really occurs in the Pitkin is relict from the Iowan series. *Griffithides*, also of doubtful Pitkin occurrence, is indicative of older strata. *Dolorthoceras eurekensis* is known from pre-Pitkin strata. *Agassizocrinus*, *Camarophoria explanata*, and the several species of *Archimedipora* are more typical of older Chester strata in Illinois, although they do carry upward in less abundance.

The writer assigns the Pitkin to the upper Chester and believes that its lower part is no older than the Clore. The Pitkin probably includes not only the Kinkaid, but also strata younger than any part of the Chester series of Illinois.

Snider (1915, p. 43) correlated the Pitkin with the Maxville limestone of Ohio and through the Maxville with the Greenbrier limestone. The writer agrees with Morse (1910, p. 108) that the Maxville is probably equivalent, at least in part to the Ste. Genevieve limestone, thus, the Greenbrier cannot be equivalent to the Pitkin. The upper Greenbrier contains some Chester beds but none as young as those of the Pitkin. The Carterville limestone of Missouri, which has been suggested as a possible correlative of the Pitkin by Snider (1915, p. 43), is lower Chester.

Beds of Pitkin age are probably included in the Chester of the Appalachians but the faunas of these eastern beds are not sufficiently well known to permit accurate correlations. Butts (1927) considered that the Parkwood bridges the Mississippian-Pennsylvanian boundary and that the basal Parkwood is equivalent to the upper part of the Pennington formation of eastern Tennessee, which, in turn, is equivalent to part of the Floyd shale. He (1927, chart opposite p. 80) considered the Floyd shale of Alabama to be equivalent to the Bangor, Pennington, and Parkwood. With the base of the Floyd placed at the horizon of the Glen Dean, it is obvious that the Pitkin is equivalent to part of the Floyd, because the top of the Floyd is uppermost Chester. It cannot be determined at present what part of the Floyd is equivalent to the Pitkin, but the Pitkin is presumably younger than the Bangor limestone or parts of the Floyd equivalent to the Bangor.

Although the Paradise formation of Arizona contains several species in common with the Pitkin, Hernon concluded (1935, p. 663) that the Paradise probably was no younger than part of the Glen Dean.

The White Pine shale of Nevada and the Pitkin contain two cephalopod species that are closely similar, if not conspecific, but a correlation based on the meager fauna of the White Pine can not be definite.

Bell (1929, pp. 66–68) gave a faunal list of the Windsor of Canada, which is of decided European character, but correlations with the Chester of the Mississippi Valley seem of doubtful validity. It does not seem likely that the fauna of the Windsor sea ever entered the mid-Continent sea of the United States. Instead, the Windsor appears to be typical of European Carboniferous seas.

[2] Correspondence, April 15, 1940.

Detailed studies of the Carboniferous corals have been made by British paleontologists, whose work has been summarized by Hudson and Turner (1933) in a paper of signal interest to all students of the Lower Carboniferous. The Chester series includes at least the English faunal zones E_1 and E_2 and probably part of the H zone; the Upper Viséan may be equivalent to part of the Chester, also.

Upper Mississippian coral faunas have been reported from China, where, according to Ting and Grabau (1936, p. 560, 561), the Upper Mississippian (Fengninian) or Shangssuan series is marked in the upper portions by the predominance of the coral genera *Syringopora*, *Caninia*, *Lithostrotionella*, and *Kweichouphyllum*. Ting and Grabau regard the fauna as typically Indo-Pacific,

> which entered the Eurasian continent in South China and Indo-China and transgressed westward to the extreme western limit of the Continent. The path of the invasion is well shown by the occurrence of this fauna in Kansu Province, Chinese and Russian Turkistan, the Ural region, the Moscow and Donetz Basins, Persia, Asia Minor, and elsewhere.

The unusual coral fauna from the Pitkin is separated from similar occurrences by considerable distances. This fauna probably never existed in the seas which covered southern Illinois during Chester time because not a single one of its genera has been recorded there. Possibly the fauna migrated down the Appalachian or Cordilleran geosyncline and thence into the Pitkin sea.

Surely the Pitkin sea was unique, bearing not only the general long-range Chester species, but relict species, species of Pennsylvanian aspect, foreign coral genera, and several rarely found genera of invertebrates.

NATURE AND SOURCE OF THE FAUNA

The characteristics of the Pitkin fauna are as follows:

1. A few species are of decided upper Chester age.
2. The fossils are, for the most part, of long Chester range and wide geographic distribution.
3. A few species occur in the Pennsylvanian and half the genera carry over into the Pennsylvanian.
4. A few other species are not known from the Pennsylvanian, but are suggestive of more advanced development than other Chester elements.
5. A few species are characteristic of earlier Chester strata and some species are closely related to or reminiscent of species from the Iowa series.
6. Individual faunal elements which would provide bases for correlating the Pitkin with some definite portion of the type Chester of the Illinois Basin are largely absent, therefore, the fauna appears to be geographically isolated.
7. Some species are unlike other known Chester fossils from the United States, but are related to certain foreign species.
8. The fossils occur abundantly at some localities but are not necessarily restricted enough to allow constructive zoning of the formation at this time.

The writer views the Pitkin sea as being a lobe of an ocean lying south of North America. In this sea the Chester faunas evolved and from it they migrated northward from time to time and the Pitkin fauna seems to record the last migration during the Mississippian period in the mid-Continent. This ocean probably endured from earliest Mississippian time and as late as Pitkin time contained relict elements of early Mississippian age. The Pitkin sea, occupying a separate basin from that of the Illinois basin, was probably sufficiently isolated geographically for the fauna to possess marked differences from the northern Chester faunas. Long range Chester species occurred in both basins, but certain distinctive guides present abundantly in Illinois are absent in Arkansas. The writer believes faunas of Pennsylvanian aspect were appearing as the last of the early Mississippian faunas were dying out, and that this condition was attained during Pitkin or late Chester time. Furthermore, faunal migration from Europe or Asia apparently reached this ocean and certain corals of unique aspect migrated northward with the Pitkin sea but were unable to cross into the Illinois basin.

Such a situation might have existed if the two basins were separated by a barrier connecting the Ozark and Nashville domes, or if a marine connection between the south-

ern and the northern (Illinois) basins were unenduring and different environments acted as an ecologic barrier. Certainly a connection existed in lower Chester time, but there appears to be no evidence that the two basins were directly joined in Pitkin time.

The recurrence of certain Mississippian species in the Morrow group can be explained similarly, on the basis of a parent ocean lying south of the present Boston Mountains. The Hale sandstone and conglomerate was deposited in a shallow post-Pitkin sea by currents capable of transporting coarse sediments and of partially reworking Pitkin sediments and their fossils. In the meantime, most, but not all of the Mississippian elements in the parent ocean had died out and true Pennsylvanian forms were added to the assemblages which typified post-Hale strata. That considerable time would be necessary to accomplish the faunal break, is evident, even though the unconformity is not structurally apparent.

FAUNAL SUMMARY

	Genera Identified	Total Described Species	Newly Described Species	Total Species
Foraminifera	1	0	0	1
Porifera	1	0	0	1
Anthozoa	8	8	4	11
Blastoidea	1	2	1	3
Crinoidea	15	7	0	23
Stelleroidea	2	1	1	2
Echinoidea	1	0	0	1
Vermes	1	0	0	1
Bryozoa	15	24	11	30
Brachiopoda	27	38	4	48
Pelecypoda	17	22	0	35
Scaphopoda	1	0	0	1
Gastropoda	24	9	4	30
Cephalopoda	6	5	1	9
Trilobita	3	3	0	4
Ostracoda	3	2	0	3
Vertebrata	4	0	0	4
Plantae	0	0	0	1
Totals	130	121	26	208

The faunal summary presented in tabular form classifies the 208 species now known from the Pitkin. Every fossil form not demonstrably a synonym or homonym has been counted. *Linoproductus prattenianus*, *Eumetria marcyi*, and *Allorisma arkansana*, all of which have been included in the fauna previously, are, in the opinion of the writer, synonyms of species already included. *Productus elegans* and *Linoproductus ovatus* are homonyms of other species and are therefore omitted. Previous works by Snider (1915) and Roth (1929) listed 64 and 50 species respectively.

SYSTEMATIC DESCRIPTIONS

Phylum COELENTERATA

Class ANTHOZOA

Order TETRACORALLA

Family CLISIOPHYLLIDAE

Genus KONINCKOPHYLLUM Thomson and Nicholson, 1876

KONINCKOPHYLLUM TALONATUM Easton, n. sp.

Plate 21, figures 3–7

External character.—Corallum simple to compound, fasciculate, cerioid; peripheral increase conspicuous. Simple coralla turbinate, apical angle about 60°; conical form predominating, little or no cylindrical development. Epitheca not reflecting septa, marked by fine encircling lines and wrinkles; talon very conspicuous. Calyx rather broad, flaring, marked by much thickened counter-cardinal septum rising above the floor; 38 to 42 major septa lining walls. Simple coralla range in length from 3 to 5 cm.

Transverse section.—Dissepimentarium occupying one-half to two-thirds of radius, consisting of small rather *V*-shaped dissepiments somewhat loosely arranged. Tabularium narrow, marked by one or several ranges of transsected tabulae; thickened columellar plate extending part way into well-developed cardinal fossula; cardinal septum short; major septa extending three-quarters of way to axis, equally thickened within tabularium. Septa less well defined in dissepimentarium, where they break up into diverging sides of dissepiments. Cardinal-counter septum continuous in younger stages, may be joined axially by alar septa. Dissepiments mostly concentric in young stages, become angular in mature stages.

Longitudinal section.—Dissepiments dense, steeply inclined. Periaxial tabulae slightly sloping distally or nearly flat; axial tabellae sharply produced distally forming angle of

FAUNAL CHART

	Occurrence	First report	Deposited	Menard	Clore	Kinkaid	Pennsylvanian
FORAMINIFERA							
Endothyra sp.	r	x	W				G
PORIFERA							
Cliona sp.	r	x	W				?
ANTHOZOA							
Amplexus sp.	r	x	W				G
Aulopora cf. *A. gracilis* Thomson	r	x	W				
Caninostrotion variablilis, n. sp.	a	x	W				
Koninckophyllum talonatum, n. sp.	c	x	W				
Lonsdaleia major, n. sp.	r	x	W				
Lonsdaleia minor, n. sp.	r	x	W				
Pleurodictyum eugenei (White)	r	x	W				x
Pleurodictyum meekanum (Girty)	c		W				
Syringopora sp.	r	x	W				G
Triplophyllum spinulosum (Edwards and Haime)	a		W	x	x	x	
Cup coral unidentified	r	x	N			x	
BLASTOIDEA							
Pentremites sp.	c		W		G	G	G
Pentremites laminatus, n. sp.	c	x	W				
Pentremites cf. *P. platybasis* Weller	r	x	W				
CRINOIDEA							
Agassizocrinus sp. 1	r	x	W		G	G	G
Agassizocrinus sp. 2	r	x	W				
Agassizocrinus sp. 3	r	x	W				
Carcinocrinus stevensi Laudon	r		T				
Catillocrinus sp.	r		T				
Cosmetocrinus sp.	r		T				
Cromyocrinus sp.	r	x	W				
Cyathocrinus sp.	r	x	N				
Delocrinus sp.	r	x	W				G
Hydreionocrinus sp.	r	x	W			G	G
Linocrinus floweri Laudon	r		T				
Pachylocrinus sp.	r	x	W				G
Pelecocrinus stereosoma Laudon	r		T				
Phanocrinus cooksoni Laudon	r		T				
Phanocrinus cf. *P. cooksoni* Laudon	r	x	W				
Poteriocrinus ? sp.	r	x	N				
Pterotocrinus sp.	r	x	W		G	G	
Scytalocrinus sp. 1	r		T				
Scytalocrinus sp. 2	r		T				
Scytalocrinus braggsi Laudon	r		T				
Scytalocrinus dunlapi Laudon	r		T				
Scytalocrinus garfieldi Laudon	r		T				
Crinoid unidentified	r	x	W				
STELLEROIDEA							
Aganaster cingulatus, n. sp.	r	x	W				
Schoenaster ? sp.	r	x	W				
ECHINOIDEA							
Archaeocidaris sp.	c	x	W		G	G	G
VERMES							
Spirorbis sp.	c	x	W				G
BRYOZOA							
Anisotrypa solida Ulrich	c	x	W				G
Archimedipora sp.	a		W		G	G	G
Archimedipora communis (Ulrich)	c	x	W				
Archimedipora distans (Ulrich)	r	x	W			x	
Archimedipora intermedia (Ulrich)	c	x	W				
Archimedipora invaginata (Ulrich)	a		W				
Archimedipora proutana (Ulrich)	c	x	W			x	

FAUNAL CHART—*Continued*

	Occurrence	First report	Deposited	Menard	Clore	Kinkaid	Pennsylvanian
Archimedipora swallovana (Hall)	a		W			x	
Batostomella sp.	c	x	W		G	?	G
Chilotrypa regularis, n. sp.	r	x	W				
Dichotrypa levis, n. sp.	r	x	U				
Dyscritella ? sp.	r	x	W				
Fenestella [*Fenestrellina*] sp.	c	x	W		G	G	G
Fistulipora introspinosa, n. sp.	c	x	W			G	G
Glyptopora michelinia (Prout)	?		U				G
Glyptopora crassa, n. sp.	a	x	W				
Lyropora solida, n. sp.	r	x	W			G	
Meekopora abrupta, n. sp.	a	x	W			G	
Meekopora tenuis, n. sp.	a	x	W				
Polypora sp.	a	x	W				
Polypora cf. *P. whitei* Ulrich	c	x	W				
Rhombopora sp.	r	x	W		G	G	G
Septopora cf. *S. biserialis* Swallow	c	x	W				G
Septopora cestriensis Prout	c	x	W		x	x	
Septopora subquadrans Ulrich	c	x	W				
Tabulipora cestriensis (Ulrich)	a	x	W		x	x	G
Tabulipora microfistulata, n. sp.	a	x	W			G	
Tabulipora poculoformis, n. sp.	r	x	W				
Tabulipora reflexa, n. sp.	c	x	W				
Tabulipora subtilis, n. sp.	r	x	W				
BRACHIOPODA							
Athyris cestriensis Snider	r		W				?
Buxtonia arkansana (Girty)	a		W		x		
Camarophoria cestriensis Snider	a		W				
Camarophoria explanata (McChesney)	c		U	x	x	x	
Chonetes oklahomensis Snider	a		W				G
Chonetes sericeus Girty	?		W				
Chonetes tumescens, n. sp.	a	x	W				
Cliothyridina sublamellosa (Hall)	a		W	x	x	x	
Composita subquadrata (Hall)	c		W		x	x	G
Composita trinuclea (Hall)	c		W	x			
Composita sp.	?						
Crania infimbriata, n. sp.	r	x	U		G	G	G
Diaphragmus ? sp.	?						
Dielasma ? sp.	r	x	W				
Dielasma arkansanum Weller			I				
Dielasma formosum (Hall)	?		U				
Dielasma illinoisensis Weller	c	x	W				
Dielasma shumardanum (Miller)	r		W		x	x	
Dielasma whitfieldi Girty	a	x	W				
Echinoconchus alternatus (Norwood and Pratten)	a		W				
Echinoconchus ? sp.	r	x	W				
Eumetria costata (Hall)	c		W	x	x	x	
Eumetria pitkinensis Snider	c		W				
Eumetria vera (Hall)	c		W				x
Girtyella indianensis (Girty)	r		U				
Hustedia sp.	r	x	W				G
Hustedia multicostata Girty	c		W				
Krotavia lucerna, n. sp.	r	x	W				
Lingula sp.	r	x	U				G
Lingulidiscina newberryi var. *moorefieldana* Girty	?						G
Lingulidiscina newberryi var. *ovata* Girty	?						
Linoproductus pileiformis (McChesney)	a		W	x	x	x	
Martinia sp.	r	x	U	x			
Orthotetes kaskaskiensis (McChesney)	c		W	x	x	x	G
Orthotetes kaskaskiensis var. ?	r	x	W				

FAUNAL CHART—*Continued*

	Occurrence	First report	Deposited	Menard	Clore	Kinkaid	Pennsylvanian
Orthotetes subglobosus var. *protensa* Girty	c	x	W				
Orthotetes suspectum (Girty)	c		W				
Productus cestriensis Worthen	a		W	x	x	x	G
Productus fasciculatus McChesney	r		W				
Pustula ? sp.	r	x	W				
Reticularia setigera (Hall)	a		W		x	x	
Spirifer leidyi Norwood and Pratten	a		W	x	G	G	G
Spirifer pellaensis Weller	a		W				
Spiriferina spinosa (Norwood and Pratten)	r		W		x	x	G
Streptorhynchus ? sp.	r	x	W				
Syringothyris aequalis, n. sp.	c	x	W				
Tetracamera sp. (*T. neogenes*?)			U				
Tetracamera neogenes Girty	c		W				
PELECYPODA							
Allorisma walkeri Weller	c		W				G
Astartella sp.	r	x	U				G
Aviculopecten batesvillensis Weller	?		W	G			G
Aviculopecten eurekensis Walcott	?						
Aviculopecten keoughensis Snider	r		W				
Aviculopecten morrowensis Girty	r		W				
Aviculopecten multilineatus Girty	r		U				
Aviculopecten pitkinensis Snider	r		W				
Conocardium sp.	r	x	U				
Conocardium peculiare Girty	?						
Cypricardella sp.	r	x	U				
Cypricardinia sp.	r	x	W				G
Edmondia crassa Girty	?						G
Edmondia crassa var. *suborbiculoidea* Girty	r		W				
Edmondia pitkinensis Snider	c		W				
Leda sp.	r	x	U				G
Leda vaseyana (McChesney)	r		W				
Leiopteria ? sp.	r		W				
Leptodesma ? sp.	r	x	U				
Myalina sp.	a	x	W			G	G
Myalina compressa Snider	c		W				
Myalina longicardinalis Snider	a		W				
Nucula illinoisensis Worthen	r		W				G
Parallelodon sp.	r	x	W				G
Pteronites sp.	r	x	U				
Schizodus sp. 1	r	x	W				G
Schizodus sp. 2	r		W				
Schizodus arkansanus (Weller)	c		W	x		G	
Schizodus chesterensis Meek & Worthen	?		W				
Schizodus depressus Worthen	r		W				
Schizodus insignis Drake	?		W				
Solenomya ? sp.	r		W				G
Sphenotus cherokeense Snider	c		W				G
Sphenotus gibsonense Snider	c		W				
Sphenotus quadriplicatum Snider	c		W				
SCAPHOPODA							
Laevidentalium sp.	r	x	W				
GASTROPODA							
Bellerophon sp. 1	r		W	G	G		G
Bellerophon sp. 2	r	x	W				
Bellerophon pitkinensis Snider	c		W				
Bucanella ? sp.	r	x	U				
Colpites ? sp.	r	x	W				G
Euphemites incarinatus, n. sp.	r	x	W				G
Clabrocingulum sp.	r	x	W				

FAUNAL CHART—*Continued*

	Occurrence	First report	Deposited	Menard	Clore	Kinkaid	Pennsylvanian
Gosseletina ? sp. 1	r	x	U				
Gosseletina ? sp. 2	r	x	N				
Helcionopsis ? *reticulatus*, n. sp.	r	x	W				
Hemizyga sp.	r	x	W				G
Holopea newtonensis Whitfield	?						
Latischisma ? sp.	r	x	N				
Leptoptygma sp.	r	x	W				G
Leptoptygma ? sp.	r	x	U				
Microptychis sp.	r	x	W				
Mourlonia angulata, n. sp.	r	x	U				
Naticopsis sp.	r	x	U	x			G
Neilsonia sp.	r	x	N				
Phanerotrema sp.	r	x	W				G
Platyceras subrotundum Snider	a		W				G
Pseudozygopleura ? sp.	r	x	U				
Sphaerodoma subcorpulenta (Whitfield)	?		W				G
Stegocoelia sp.	r	x	U				
Straparolus planidorsatus (Meek and Worthen)	r		W				G
Straparolus triliris, n. sp.	r	x	W				
Strobeus sp.	r	x	U				
Strobeus ? sp.	r	x	N				
Strophostylus sp.	r		W				G
Conularia sp.	r	x	W			G	G
CEPHALOPODA							
Coloceras [*Leuroceras* ?] sp. 1	r		W				G
Coloceras sp. 2	r	x	W				
Cravenoceras cf. *C. hesperium* Miller and Furnish	r	x	U				
Cycloceras randolphensis (Worthen) ?	r		W				
Cycloceras sequoyahensis Snider	r		W				
Dolorthoceras ? *eurekensis* (Walcott) ?	r		W				G
Dolorthoceras ? sp.	r	x	W				
Eoasianites globosus, n. sp.	r	x	W				G
Mooreoceras sp.	r		I				G
TRILOBITA							
Griffithides sp.	?						
Griffithides pustulosus Snider	?						
Kaskia chesterensis J. M. Weller	c	x	W				
Paladin mucronatus (Girty)	a		W				
OSTRACODA							
Glyptopleura inoptina Girty	r	x	N				G
Paraparchites sp.	r	x	U				G
Primitia fayettevillensis Girty	r	x	U				
VERTEBRATA							
Cladodus sp.	r	x	W				
Deltodus sp.	r	x	W				
Petalodus sp.	r	x	W				
Spine, unidentified	r	x	U				
PLANTAE							
Encrusting alga	r	x	W				

KEY

r—rare
c—common
x—first report or species present
a—abundant
?—doubtful
G—genus present

W—Walker Museum
U—U.S. Geological Survey
T—University of Tulsa
I—State University of Iowa
N—National Museum

about 45 to 60 degrees with thickened median plate; density of tabulae about 12 in 0.5 cm.

Comparison.—This species differs from *K. magnificum* in the more acute axial tabellae, broader dissepimentarium, thicker median plate, and fewer septa. It differs from *K. interruptum* chiefly in the persistent median plate, broader dissepimentarium, and septa of nearly equal strength.

Types.—Holotype, U. C. 48257 from locality 10; ideotype, U. C. 48259 from locality 6.

Family CANINIIDAE

Genus CANINOSTROTION Easton, n. gen.

Diagnosis.—Compound rugose corals multiplying asexually chiefly by "peripheral increase" but possibly also by basal division. Cardinal fossula conspicuous in all but early stages, formed by down-bending of tabulae and shortening of cardinal septum. Dissepimentarium broad; dissepiments tend toward angulo-concentric pattern. Pseudocolumella intermittently developed, variable, formed by junction of axial ends of some major septa combined with the distal arching of tabulae. Tabulae strong, irregularly arranged. Typically, septa are equally thickened in all quadrants.

The genus differs from *Caninophyllum* Lewis, 1929 in being compound, in having major septa typically equally thickened in all quadrants, in having a well-developed pseudocolumella, and in having much shorter minor septa than in *Caninophyllum*. It differs from *Bothrophyllum* Trautschold, 1879 in the same manner, but the pseudocolumella is stronger and more persistently present in late stages. The pinnate arrangement of the septa adjacent to the cardinal septum is obscure, if present at all. There is no flattening of tabulae in the adult.

Genotype, *Caninostrotion variabilis*, n. sp.

Occurrence.—Widespread in the Pitkin formation (uppermost Chester) of Arkansas.

CANINOSTROTION VARIABILIS Easton, n. sp.

Plate 21, figures 14–16

External character.—Conical proximally, rapidly attaining cylindrical shape. Talon inconspicuous, sometimes more than one present. Epitheca thin, marked by extremely fine encircling striae; rugae commonly present. Calyx subcircular to oval, very deep, floor crossed by major septa, many uniting axially. Cardinal fossula well developed, narrow, typically lying on shorter or inwardly bent side of corallite and not tending towards rotation; other fossulae lacking. Simple specimens range in length from 3 to 8 cm., in width from 1.5 to 4.5 cm. greatest diameter; largest corallum 11 cm. long and 9 cm. in greatest width, with at least three ranges of corallites.

Transverse section.—Major septa in mature regions 38 to 46; cardinal septum usually short, flanked on each side by one or two major septa tending to enclose fossula but not joining ends; major septa typically, but not invariably, equally thickened, one section showing added septal stereozone in cardinal quadrants; thickening only within tabularium, septa tapering axially; ends of a few majors commonly joined at weak pseudocolumella; minor septa not completely crossing into tabularium, except in very young stages; minor septa slightly thinner, more irregular than extrathecal portions of majors. Tabularium occupies one-third or less of radius. Dissepimentarium broad; outer dissepiments very angular for a few rows, most others angulo-concentric, except for the innermost concentric series where dissepiments may be somewhat thickened.

In immature regions, sections show narrow dissepimentarium not present in earliest stages, consisting principally of concentric dissepiments. Fossula less well marked than in advanced stages. In very early stages few major septa always unite at axis and cardinal septum is long and slightly thicker than other septa.

Longitudinal section.—Dissepimentarium absent in very early stages, first represented by single row of vesicles; in mature stages dissepimentarium may occupy two-thirds of radius; outermost dissepiments closely packed; innermost dissepiments less closely packed but noticeably thickened. Inner wall indicated but not invariably present. Active growth stages indicated in dissepimentarium by broadly S-shaped rows of dissepiments. Tabulae highly variable, broadly to sharply arched; tabulae arched axially to meet axial ends of some major septa thereby forming pseudocolumella; density of tabulae

rather irregular about 20 to 22 in 1 cm., some tabulae incomplete.

Comparison.—This species differs from *Bothrophyllum longiseptum* (Lewis), (formerly called *Pseudocaninia*) which it resembles somewhat, in having a more pronounced pseudocolumellar structure, even in mature stages. Its minor septa are located within the dissepimentarium, except occasionally in young stages, and the septal stereozone is not typically greater in the cardinal quadrants than elsewhere.

Types.—Holotype, U. C. 48367 from locality 4; paratype, U. C. 47203 from locality 4; ideotype, U. C. 48272 from locality 3. This is one of the most common Pitkin fossils, occurring at almost every locality, sometimes in great abundance.

Remarks.—Because added septal stereozone in the cardinal quadrant was observed in only one transverse section out of the many dozens observed, this feature must be an aberration here.

Family LONSDALEIIDAE
Genus LONSDALEIA McCoy, 1849
LONSDALEIA MAJOR Easton, n. sp.
Plate 21, figures 11–13

External character.—Corallum compound, massive, cerioid, prismatic in young regions, fasciculate and phaceloid in mature regions. Colony about 15 cm. in diameter, roughly spherical, corallites radiating from center of base. Average diameter of calices varies from 1.5 to 2.0 cm. in mature regions. Epitheca moderately thick with prominent interseptal ridges and fine encircling striae. Calyx depressed periaxially, a calicular boss rising above depressed portion; about 32 major septa present in ephebic portions.

Traverse section.—Dissepimentarium consisting of several rows of large, irregularly shaped dissepiments, septa faintly mirrored within dissepimentarium as ridges on some dissepiments. Lonsdaleioid retreat of septa very pronounced in late mature regions, commonly lacking in early mature regions. An inner wall (sclerotheca) formed by thickening of densely packed dissepiments. Inner zone consists of thickened major septa, about 32 of which extend almost to the axial complex; thin minor septa intercalated between them extend very short distance within sclerotheca. Calicular boss formed of thin lamellae aligned with major septa and of distally arched tabellae; axial complex resembles spider's web in transverse section.

Longitudinal section.—Dissepiments flatly convex axially, forming one to four rows in dissepimentarium. Inner wall formed by thickening of some dissepimental tissue. Tabulae convex proximally, very thin, sparse. Tabellae very fine, densely packed, arching up steeply, meeting broadly sinuous lamellae. Axial complex occupies from one-third to one-half of radius. Outline of each corallite marked by several evenly rounded swellings not distinct enough to be termed rugae.

Comparison.—This species differs from *Lonsdaleia duplicata duplicata* by having a more fasciculate corallum in ephebic stages, more numerous septa, and smaller dissepiments. It can be distinguished from *L. pictoense* (Billings) by its larger size, much more numerous septa, prominent axial complex, and broad dissepimentarium.

Type.—Holotype, U. C. 48261; locality 48.

LONSDALEIA MINOR Easton, n. sp.
Plate 21, figures 1, 2

External character.—Corallum compound, massive, cerioid, composed of prismatic corallites whose polygonal cross sections vary from three- to seven-sided. Colony 6.2 cm. long, about half as wide, about one-third as thick. Corallites from 3 mm. to 10 mm. in diameter. Holotheca not observed; epitheca thick. Calyx deep, walls steepest near periphery, calicular boss present in axial region. Maximum number of septa observed, 20.

Transverse section.—Epitheca marked by low interseptal ridges. Dissepimentarium occupies at most one-third of radius. Major septa considerably contorted, thickened by sclerenchyme, extending axially short distance from dissepimentarium, most reaching epitheca. Minor septa very short, commonly only twice as long as thickness of epitheca. Dissepiments considerably thickened. Lonsdaleioid retreat of major septa not pronounced; some minor septa reflected on axial side of dissepiments. Periaxial tabulae irregularly located, sparse. Axial tabellae arched distally making a spider's web pattern in conjunction with lamellae. Median

septum quite distinct in young stages.

Longitudinal section.—Dissepimentarium occupies one-third of radius at most; dissepiments large, thin, steeply inclined. Tabulae thin, sparse, broadly arched distally. Tabellae fine, densely packed, contorted, arched steeply distally. Single outer row of dissepiments much thickened, very pronounced.

Comparison.—This species differs from *L. major*, n. sp. in the smaller corallites, fewer and shorter major septa, less broad dissepimentarium, and narrower and simpler axial complex. It differs from *L. floriformis floriformis* in the less broad dissepimentarium, commonly fewer septa, thickened dissepiments, and presence of interseptal ridges.

Type.—Holotype, U. C. 48256; locality 26.

Suborder TABULATA
Family FAVOSITIDAE
Genus PLEURODICTYUM Goldfuss, 1829

Remarks.—Lang, Smith, and Thomas have reported their belief (1940, p. 102) that *Pleurodictyum* is a senior synonym of *Michelinia* de Koninck, 1841. According to these authors (1940, p. 85), the same opinion had been indicated by some authors, but it has not been consistently followed. Hall (1867) apparently considered *Pleurodictyum* to be a subgenus of *Michelinia* (or *Michelina* as Hall spelled it in that publication).

Moreover, Lang, Smith, and Thomas (1940, p. 85) include all the subgenera of *Michelinia* in the synonymy of *Pleurodictyum; Eumichelinia* Yabe and Hayasaka, 1915 is included objectively because these three authors chose identical genolectotypes (p. 58) for *Eumichelinia* and *Michelinia; Procteria* Davis, 1887 they included subjectively (p. 105); *Protomichelinia* Yabe and Hayasaka, 1915 they included subjectively (p. 107).

Genotype, *Pleurodictyum problematicum* Goldfuss.

PLEURODICTYUM EUGENEI (White)

Michelinia eugeneae WHITE, *1884*, 13th Ann. Rept. Indiana Geol. Survey, p. 119, pl. 23, figs. 14–16.
[?] *Michelinia branneri* MILLER and GURLEY, *1894*, Illinois St. Mus. Nat. Hist., Bull. 3, p. 68, pl. 7, figs. 12, 13.
Michelinia eugeneae, BEEDE, *1900*, Kansas Geol. Survey, vol. 6, p. 21, pl. 2, figs. 12–12b.
[?] *Michelinia eugenae*[*sic*]. YAKOVLEV, *1903*, Mem. Geol. Comm., N. S., no. 12, pp. 7–15, pl. 1, figs. 3, 5.
Michelinia eugeneae, MATHER, *1915*, Bull. Sci. Labs. Denison Univ., vol. 18, p. 95, pl. 1, figs. 17, 17a; pl. 2, fig. 1.
Michelinia eugeneae, EASTON, *1942*, Arkansas Geol. Survey, Bull. 8, pl. 1, fig. 4.

Remarks.—*P. eugenei* can be told from *P. meekanum* by the much smaller size of the corallum and of the corallites and by the very thin tabulae. This species is common in the Morrow but has not hitherto been reported from the Mississippian.

Material.—Walker Museum nos. 48282, 48283, 48284; localities 6, 8, and 23.

PLEURODICTYUM MEEKANUM (Girty)

Michelinia meekana GIRTY, *1910*, Ann. New York Acad. Sci., vol. 20, no. 3, p. 189.
Michelinia meekana, SNIDER, *1915*, Oklahoma Geol. Survey Bull. 24, pt. 2, p. 71, pl. 3, figs. 9–11.

Phylum ECHINODERMATA
Class BLASTOIDEA
Order EUBLASTOIDEA
Genus PENTREMITES Say, 1820
PENTREMITES LAMINATUS Easton, n. sp.
Plate 21, figures 9, 10

Description.—Body of medium size, height and width very nearly equal; greatest width at distal ends of ambulacra. Dimensions of a well-preserved specimen are: height 13.5 mm., greatest width 14.0 mm., length of ambulacra 13.3 mm., greatest width of ambulacra 3.9 mm.

Dorsal region convex; when seen laterally, outline a broad, low, truncate, pyramid. Stem facet and adjacent trifoliate callosity slightly elevated; latter with lobes and sutures coinciding. Basal plates extend about one-third of distance from center of stem facet to distal parts of ambulacra; each basal with pronounced outward swelling coextensive with dorsal ambulacral regions, not reaching quite as high as stem facet, least prominent swelling on smallest basal. Dorsal ambulacral regions increasingly prominent toward lower ambulacral extremities. Interambulacral areas curving gradually away from ambulacral regions, broadly *V*-shaped with barely perceptible furrow marking each suture.

Ventral region gently convex with sides sloping to truncate summit. Ambulacral areas about one-third as wide as long, *V*-shaped in cross-section, side plates most convex distally. Lateral grooves 10 in 3 mm., inclined medially and proximally in distal region, becoming transverse in proximal region. Interambulacral areas increasingly broadly concave below, becoming *V*-shaped dorsally, proximal ends plate-like, extending somewhat above summit. Lateral margins of interambulacra abruptly and evenly elevated, coalescing to form plate-like proximal ends. Deltoid plates slightly less than one-half as long as ambulacra, sutures straight, meeting at less than 90 degrees.

Comparison.—This species is most closely allied to *P. brevis* Ulrich, differing from it in the smaller basal plates, more elevated stem facet and callosity, narrower and more acutely *V*-shaped ambulacra, and flat deltoid plates with a plate-like ventral extension. The species differs from *P. platybasis* Weller in its convex dorsal region and its subangular interambulacra with pronounced elevations of the lateral margins.

Types.—Holotype, U. C. 48293; paratypes, U. C. 48294; all from locality 30.

Some specimens of *P. brevis* in Walker Museum exhibit flattened triangular areas in the interambulacra, each being bounded by the lateral ambulacral margin, the adjacent dorsal half of the deltoid suture, and a faint ridge connecting the dorsal point of the deltoid plate and the dorsal extremity of the ambulacra.

Remarks.—*P. laminus* n. sp. occupies a position intermediate between *P. brevis* and *P. platybasis*, at least in most structural details. Specimens from near Leslie, Arkansas, exhibit noticeable growth markings. In young individuals the basal region is produced dorsally, with the callosity and stem facet extending beyond the surface of the basals.

Class STELLEROIDEA
Subclass ASTEROIDEA
Order CRYPTOZONIA
Genus SCHOENASTER Meek and Worthen, 1860
SCHOENASTER? sp.
Plate 21, figure 8

Remarks.—Only part of one arm is known; the fragment is 7.0 mm. long and 2.2 mm. wide at the widest place, the distal portion of the fragment being narrower than the proximal part. Nine oval adambulacral plates are present on each half and are alternate in position. The largest of these plates are about 1 mm. long and 0.5 mm. wide. The adambulacrals are located with the long axes diagonal to the axis of the ray and are proximally directed. No fewer than 9 spine bases consisting of minute depressions on the adambulacrals are arranged linearly toward the distal part of the plates and are aligned ventrally and proximally, hence, the spines pointed distally. The ventral surface is exposed and the ambulacral groove extends at least part way along the arm. No sutures can be observed on the floor of the groove.

This specimen is referred to *Schoenaster*, a genus of true asteroids, but the absence of the disc renders the reference doubtful. In size of plates and proportions of the arm, the Pitkin fragment resembles *S.* (?) *montanus* Raymond from the Madison limestone of Montana. Although some preparation of the specimen has been attempted, no trace of the disc has been found. The disc of *Schoenaster* is pentagonal and the apex of each angle is orientated in line with a ray.

Material.—U. C. 48292; locality 32.

Genus AGANASTER Miller and Gurley, 1890
AGANASTER CINGULATUS Easton, n. sp
Plate 24, figures 9, 10

Disc circular, usually distorted in preservation, greatest diameters of specimens 3.0 mm. to 3.6 mm. Dorsal surface seemingly formed of imbricating plates, arrangement not accurately determinable, probably in two circlets. Indistinct radial swellings seem to coincide with some plates. Body probably comparatively thick because shape of arms is not indicated on dorsal surface. Ventral surface gently convex; two segments of arms extending within periphery of disc, being progressively more incorporated within it. Interambulacral regions consist of polygonal plates; genital slits located beside arms near their origins. Marginalia in vertical band or girdle encircling disc.

Arms subcylindrical, tapering to tips, somewhat depressed dorsally and ventrally,

and presumably capable of considerable lateral, as well as vertical, flexibility. A segment adjacent to disc of one specimen measures 0.49 mm. in length, 0.80 mm. in greatest width, being somewhat narrower proximally. Segments near tips of arms only slightly shorter, much narrower than proximal segments. One isolated arm retains 21 articulated segments, usually fewer are preserved on arms attached to discs. Each segment partially inclosed by paired spineless side plates separated by straight sutures dorsally and ventrally, ventral suture a trifle shorter than dorsal. Dorsal plate triangular or quadrangular, snugly fitting, slightly overlapping adjacent side plates. Ventral plate separated from side plates laterally by narrow clefts.

"Jaws" (actually merely supporting structures) separated from proximal ends of arms by sutures. Tori (separating teeth and jaws) tiny, attached to adjacent members of paired jaws which touch at interambulacral margins, diverge at tips. One jaw measures 0.42 mm. in length. Mouth-angle plates apparently fused to first ambulacrals. No teeth observed.

Comparison.—This species is closely allied to the only other known species of the genus, *Aganaster gregarius* (Meek and Worthen), from the Keokuk beds of Crawfordsville, Indiana. It differs from *A. gregarius* in the consistently smaller diameter of the disc, in possessing longer jaws with straight interambulacral margins, and in the absence of spines or spine bases on its side shields. In this last character the species resembles some European specimens from the "*Crangopsis* beds" of Fife which Spencer considered too closely allied to the Keokuk forms to warrant separation.

Types.—Holotype and paratypes on one piece of limestone, U. C. 48291; from locality 24.

Remarks.—The Pitkin specimens definitely show the ventral plate to lie below and to be distinct from the vertebral ossicle. The presence of a ventral plate has not been definitely established heretofore in this genus, and it was thought that it might be absent and that the vertebral ossicle of each segment might be the structure seen.

The material studied consists of 14 relatively complete individuals and many isolated sections of arms. The dorsal side is exposed on only one specimen. This fact is important from an ecologic standpoint, for today many ophiuroids are burrowing forms which rest with the ventral side up and only have the tips of the arms extending out of the soft bottom deposits. Such a position as this would explain why the fossil Pitkin specimens almost invariably lack the tips of the arms, but are otherwise complete, with the ventral side commonly uppermost. These Pitkin ophiuroids may have been washed into their present location on the slab, but the evidence seems strong that they have weathered out of the rock in the position in which they died.

Phylum MOLLUSCOIDEA
Class BRYOZOA
Group ECTOPROCTA
Order GYMNOLAEMATA
Suborder CYCLOSTOMATA
Family FISTULIPORIDAE
Genus FISTULIPORA McCoy, 1849

FISTULIPORA INTROSPINOSA Easton, n. sp.

Plate 22, figures 1, 2

Zoarium lobate, subramose, or with combinations of these characters. Branches and lamellae from 1 mm. to 5 mm. broad. A colony may attain diameter of one foot or more. Surface with 11 subcircular apertures in 5 mm., no apparent interstitial tissue, maculae, or monticules.

Tangential section.—Zooecia 0.3 to 0.5 mm. in diameter, thick-walled, subcircular to angular, lunaria commonly obscure. Vesicles surrounding zooecia variable in size and distribution, commonly not visible except as broken line or lines. Portions of vesicle walls project into zooecia, giving latter pseudoseptate appearance.

Longitudinal section.—Zooecia curving out from immature region, become relatively straight, meeting surface at about right angles. Diaphragms thin, unperforated, slightly concave, slightly less than one tube diameter apart, occurring throughout length of the zooecia, about 5 in 1 mm. Zooecia thick-walled near surface. Vesicles irregularly placed about 1 to 3 between zooecia, with schlerenchymous deposit on upper surfaces. Walls of vesicles project notably into zooecia as short bars generally inclined distally.

Comparison.—This species differs from

F. excelens Ulrich in having smaller vesicles and in possessing vesicular projections within the zooecia. This latter character also serves to distinguish it from other species of *Fistulipora*. The Pitkin material is not preserved well enough to display all surface details.

Types.—Holotype, U. C. 48197; paratype, U. C. 48198; all from locality 8.

Genus CHILOTRYPA Ulrich, 1884
CHILOTRYPA REGULARIS Easton, n. sp.
Plate 22, figures 3, 4

Zoarium ramose, branches bifurcating, 1 to 2 mm. in diameter. Apertures oval, 5 in 2 mm., in definite oblique ranges and imperfect longitudinal rows, with pronounced peristomes produced proximally into hoods. Interzooecial spaces depressed, smooth, occasional broader areas trending obliquely between zooecia.

Transverse section.—Axial tube subcircular, 0.41 mm. to 0.82 mm. in diameter. About 15 subequal trapezoidal axial zooecia radially surround axial tube, partly bordered outwards by larger irregularly shaped zooecia. First ring of trapezoidal zooecia may be absent in sections near proximal end of zoarium. About 11 large oval zooecia in last ring separated by vesicular tissue typically filled with sclerenchyme near surface. Some of outer zooecia connected by small pores.

Tangential section.—Zooecia oval, about 0.18 mm. by 0.29 mm. in diameter, interspaces filled with small irregularly shaped vesicles in deep sections, by dense sclerenchyme in shallow sections. Zooecial walls most pronounced in shallow sections.

Longitudinal section.—Axial tube intermittent because of contortions. Small and nearly parallel encircling zooecia commonly contain diaphragms at region of branching. Second circle of zooecia derived from first by budding from outer walls, diverging from axis at small angle, bent abruptly outward at at about half length, inclined about 60 degrees at surface; diaphragms, one, rarely two, commonly absent. Zooecial walls quite thin axially, somewhat thicker midway to surface, very strong in mature region.

Comparison.—This species differs from *C. hispida* Ulrich in having 5 zooecia in 2 mm., rather than 8 or 9 in one-tenth inch (2.54 mm.) *C. hispida* has 7 to 9 zooecia in the first circle surrounding the axial tube, whereas this species has about 11 such cells around a much larger axial tube. The zooecial walls in tangential section do not become laminar distally in this species, although there is some reduction in thickness.

Type.—Holotype, U. C. 47200; locality 23.

Genus MEEKOPORA Ulrich, 1890
MEEKOPORA ABRUPTA Easton, n. sp.
Plate 22, figures 5, 6

Zoarium unilamellar, 2 mm. to 6 mm. thick. Zooecia circular with slightly raised rims, 10 or 11 in 5 mm. Monticules about 2 mm. across, about 5 mm. between centers rising about 1.5 mm. above general surface. Epitheca very thin. Vesicular tissue increasing in area of monticules where zooecia are slightly larger.

Tangential section.—Typical zooecium measures 0.30 mm. in width, walls of rather thick sclerenchymous nature, measure 0.40 mm. through. Lunarium obsolete. Vesicles rounded, generally in a single row separating adjacent zooecia, which are encircled by about 9 vesicles. Abnormally large zooecia apparently formed by fusion or coalescence of two normal zooecia. Vesicles in monticules smaller, less rounded, generally in two rows between adjacent zooecia.

Longitudinal section.—Lamella originating from zooecia of unilamellar type, expanding in opposite direction from original growth, forming pseudobifoliate frond. Zooecia with 4 or fewer unperforated occasionally slightly concave diaphragms about one and one-half tube diameters apart, located near origins of zooecia. Vesicles arranged as somewhat parallel crescentic lines 0.08 mm. high, about three times that width, generally covered with a thin sclerenchyme on upper surface. Zooecia originating parallel with epitheca, quickly turning upwards and proceeding to surface at constant angle.

Comparison.—This species differs from *M. eximia* Ulrich in abrupt deflection of the zooecia from point of origin to surface, thicker zooecial walls, fewer diaphragms, larger zooecial apertures, and apparently a unilamellar structure.

Types.—Holotype, U. C. 48188; paratype, U. C. 48189; all from locality 15.

MEEKOPORA TENUIS Easton, n. sp.
Plate 22, figures 7, 8

Zoarium unilamellar, with zoarial characters similar to preceding species.

Tangential section.—Characters similar to preceding species, except that lunarium is better defined and vesicles within monticules are not numerous.

Longitudinal section.—Extremely thin diaphragms set at varying angles, and not restricted to the portions near origins of zooecia. Diaphragms may be slightly concave, about one tube diameter apart. Vesicles small, lack sclerenchymous layer except near surface of zoarium. Zooecia parallel surface of zoarium for only about one tube diameter, then turn to meet surface at about right angles.

Comparison.—This species differs from *M. abrupta*, n. sp., chiefly in the thinner diaphragms, which are set throughout the tubes at angles oblique to the zooecial walls. Also, this species has smaller vesicles with the sclerenchyme layer present only near the zoarial surface. It differs from *M. eximia* Ulrich in the same way as *M. abrupta*, n. sp. The latter species could be derived from *M. tenuis*, n. sp. by thickening of the diaphragms, increase in sclerenchyme within the vesicles, and more regular placement of the diaphragms.

Type.—Holotype, U. C. 48190; locality 7.

Suborder TREPOSTOMATA
Family BATOSTOMELLIDAE
Genus TABULIPORA Young, 1883
TABULIPORA CESTRIENSIS (Ulrich)

Remarks.—The Pitkin material makes it possible to add one important point to the original description, namely, that the laminar portion of the zoarium merges into subcylindrical ramose portions of the zoarium 15 mm. to 20 mm. in greatest diameter.

Material.—Plesiotypes; U. C. 48183 from locality 7; 48184 from locality 17.

TABULIPORA MICROFISTULATA
Easton, n. sp.
Plate 22, figures 9, 10

Zoarium laminar at basal expansion, rising to ramose stems 1.5 cm. to 2 cm. in diameter. Zoarium about 15 cm. in longest dimension, about 5 cm. wide and high. Surface details not visible.

Tangential section.—Zooecia subcircular, about 0.23 mm. in diameter, about 12 zooecia in 3 mm., combined width of thick adjacent walls 0.04 mm. to 0.08 mm. Acanthopores small, irregularly arranged, at angles or between angles of zooecia; in the latter case almost invariably protruding into one or both adjacent zooecia. Adjacent zooecial walls separated by more or less well defined dividing line showing fundamental polygonal shape of zooecia. Walls locally speckled with numerous, scattered, minute, dark spots. Mesopores fairly common, irregular in outline, usually less than half as wide as zooecia. Perforations in diaphragms large, about one-half the diameter of the diaphragms. Lunaria not observed.

Longitudinal section.—Zooecia inclined about 45 degrees to axis of stem, straight in immature region, curving outward in mature region, becoming normal to surface. Walls very ragged, moniliform, swellings commonly coalesced throughout their extent; broadly wrinkled in immature region;

EXPLANATION OF PLATE 21

FIGS. *1, 2—Lonsdaleia minor*, n. sp. *1*, transverse section, ×6; *2*, longitudinal section showing large dissepiments, ×6; U. C. 48256. holotype. (p. 135)

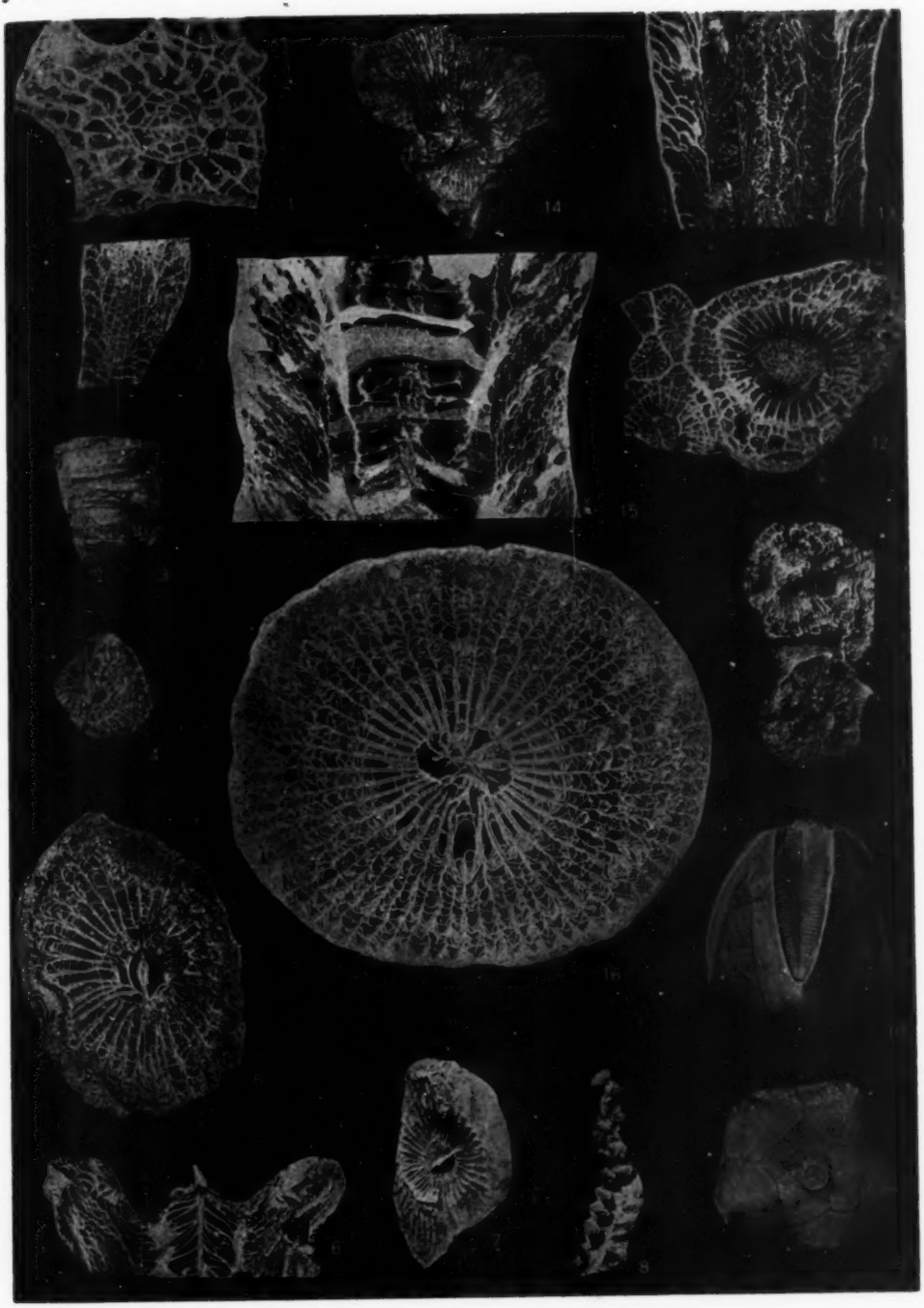
3–7—Koninckophyllum talonatum, s. sp. *3*, corallite, ×½, U. C. 48259, ideotype. *4*, early ephebic transverse section, ×2; *5*, late ephebic transverse section, ×2; *6*, longitudinal section, ×2; *7*, calyx, ×2; U. C. 48257, holotype. (p. 129)

8—Schoenaster? sp. Portion of an arm, ×4; U. C. 48292. (p. 137)

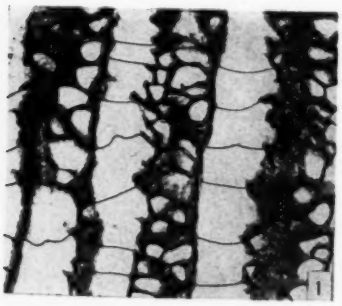
9, 10—Pentremites laminatus, n. sp. *9*, basal view, ×2; *10*, lateral view, ×2; U. C. 48293, holotype. (p. 136)

11–13—Lonsdaleia major, n. sp. *11*, calices, ×1; *12*, transverse sections, ×2; *13*, longitudinal section, ×2; U. C. 48261, holotype. (p. 135)

14–16—Caninostrotion variabilis, n. gen., n. sp. *14*, calyx, ×1; U. C. 47203, paratype. *15*, longitudinal section, ×2; U. C. 48272, ideotype; *16*, late ephebic transverse section, ×2; U. C. 48367, holotype. (p. 134)



Easton, Pitkin Fauna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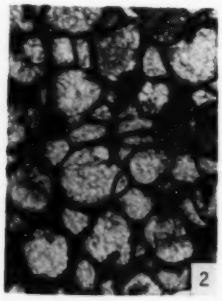
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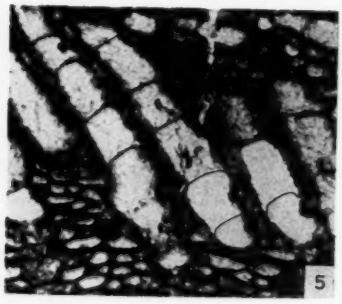
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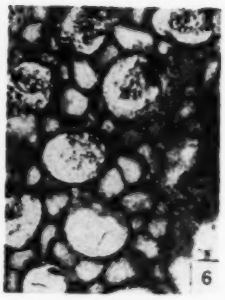
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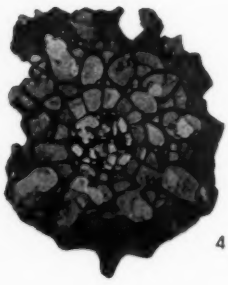
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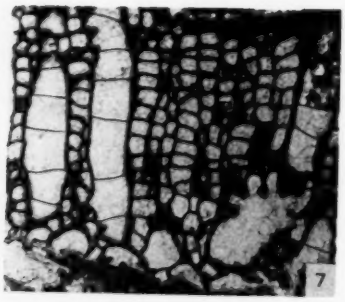
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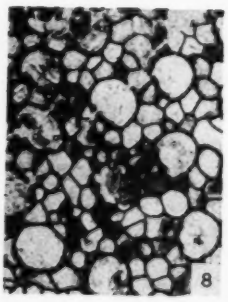
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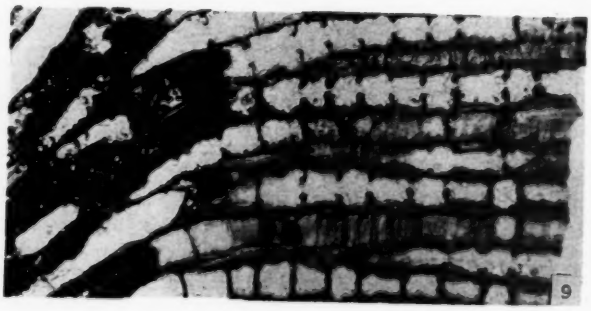
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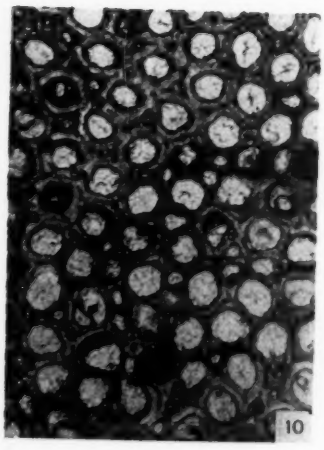
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compactly wrinkled, much thicker in outer three-fourths of mature region. Diaphragms, perforated, 14 to 17, separated by one-half to one tube diameter in mature region, rims of perforations slightly thickened.

Comparison.—This species differs from *Tabulipora cestriensis* Ulrich chiefly in the large ramose (as well as laminar) zoaria, the more ragged zooecial walls, and the larger acanthopores. R. S. Bassler,[3] who compared this specimen with the holotype of *T. meekana* Ulrich, which it resembles most closely, reports that

> . . . the zooecia are thinner walled and of less diameter than in the type form.

Type.—Holotype, U. C. 48187; locality 8.

TABULIPORA POCULOFORMIS
Easton, n. sp.
Plate 23, figures 1, 2

Zoarium bilamellar, consisting of superimposed layers 0.9 to 1.1 mm. thick, rather than of opposed lamellae with mesotheca. Surface with low monticules, 4 mm. between centers, about 2 mm. in diameter. Polygonal zooecia thickwalled, 13 to 14 in 5 mm. Other surface details not preserved.

Tangential section.—Typical zooecium 0.3 mm. wide; maximum combined width of adjacent walls 0.04 mm. Acanthopores rather large, forming swellings at and between the angles of zooecia. Adjacent zooecial walls separated by thin dividing line. Mesopores subcircular, fairly abundant, diameters about one-fourth those of the zooecia. Strong, geniculate, hooklike processes extending from walls into some zooecia may be vestigial lunaria. Perforations in the diaphragms large, diameters about one-third those of zooecia.

Longitudinal section.—Zooecia arising from very thin contorted epitheca at angle of about 30 degrees, evenly curved, becoming normal to surface, resembling elongate drinking cups. Zooecial walls rather contorted, thickest near surface. Swellings in the mature portion of moniliform zooecial walls elongate, commonly ragged. Each zooecium commonly with 5 or exceptionally 7 or 8 perforated diaphragms, one-half tube diameter apart, with edges of perforations reflexed or swollen, forming prominent terminations of diaphragms at perforations. Superimposed laminae separated by two or three rows of vesicles, each about half as wide as zooecia.

Comparison.—This species differs from *T. rudis* Ulrich in the leaflike zoarium and the low monticules, and, according to R. S. Bassler,[4] who kindly compared this species with the type of *T. rudis*,

> . . . in the slightly smaller zooecia, with thinner walls, with the beading of the walls less developed and with the perforated diaphragms more crowded.

The holotype may possibly be the basal expansion of a zoarium.

Type.—Holotype, 48182; locality 8.

TABULIPORA REFLEXA
Easton, n. sp.
Plate 23, figures 3, 4

Zoarium ramose, rather regularly branched every 1.5 cm. to 2 cm., branches arising from encrusting conical base 2 cm. wide and 5 mm. high.

Tangential section.—Zooecial apertures subcircular, 0.2 mm. in diameter, 3 in space of 1 mm. Combined thickness of walls commonly about 0.1 mm., but may be twice as

[3] Correspondence, April 29, 1940.

[4] Correspondence, April 29, 1940.

EXPLANATION OF PLATE 22

FIGS. *1, 2—Fistulipora introspinosa*, n. sp. *1*, longitudinal section, ×20; *2*, tangential section, ×20; U. C. 48197, holotype. (p. 138)

3, 4—Chilotrypa regularis, n. sp. *3*, longitudinal section, ×20; *4*, transverse section, ×20; U. C 47200, holotype. (p. 139)

5, 6—Meekopora abrupta, n. sp. *5*, longitudinal section, ×20; *6*, tangential section, ×20; U. C. 48188, holotype. (p. 139)

7, 8—Meekopora tenuis, n. sp. *7*, longitudinal section, ×20; *8*, tangential section, ×20; U. C. 48190, holotype. (p. 140)

9, 10—Tabulipora microfistulata, n. sp. *9*, longitudinal section, ×20; *10*, tangential section, ×20; U. C. 48187, holotype. (p. 140)

thick. Acanthopores large, with centrally located dark spots at most of interzooecial angles. As many as 4 similar dark spots commonly situated in line separating adjacent zooecial walls. Mesopores rare, about half as wide as zooecia.

Longitudinal section.—Tubes in axial region not moniliform, lacking diaphragms, rather straight walled, slightly inclined toward mature region, becoming crooked, sharply curved, meeting surface at right angles. Zooecia with 8 or 9 perforated diaphragms less than one tube diameter apart. Zooecial walls moniliform, some of adjacent swellings fused, exceedingly thick and ragged.

Comparison.—This species differs from *T. carbonaria* (Worthen) in the less massive branches, closer spacing of zooecial apertures, tubes bending more abruptly at the mature region, and much more moniliform walls. Weathering has obliterated details of the surface.

Type.—Holotype, U.C. 48191; from locality 20.

TABULIPORA SUBTILIS
Easton, n. sp.
Plate 23, figures 5, 6

Zoarium ramose, stems ovate in cross-section, diameters of the paratype 8 mm. and 5.5 mm. Monticules with slightly larger zooecial apertures, very low, 3 to 4 mm. between centers. Apertures polygonal but irregularly shaped, 21 or 22 in 5 mm.

Tangential section.—Zooecia very thick-walled, polygonal shape modified by sclerenchyme so that cross-sections are subcircular. Diameters of zooecia from 0.15 to 0.30 mm.; maximum combined width of adjacent walls 0.08 mm. which is about twice average thickness. Adjacent zooecial walls separated by strong dividing line. Acanthopores rather strong at or near angles, may extend short distance within zooecia. Dark spots on dividing line between acanthopores, minute, sparse. Mesopores fairly common, variable in size, averaging about one-third as wide as zooecia. Diameter of perforations in diaphragms about two-fifths zooecial diameter. No trace of lunaria observed.

Longitudinal section.—Walls of the zooecia broadly wrinkled in immature region. Zooecia curve away from axis of stem, greatest curvature being at inner part of mature region. Zooecia thicker-walled in mature region, moniliform, commonly with one swelling between each set of diaphragms. Diaphragms 7 or 8, perforated with thickened rims, about one-half tube diameter apart.

Comparison.—This species differs from *T. ramosa* Ulrich in the presence of 2 or 3 more diaphragms in each zooecium, and, as reported by R. S. Bassler,[5] who kindly compared this specimen with the holotype of *T. ramosa*, it is

> . . . similar to the type specimen, but the zooecia are decidedly smaller, thinner walled and with less developed acanthopores.

Type.—Holotype, U.C. 48180; locality 7.

Suborder CRYPTOSTOMATA
Family FENESTELLIDAE
Genus ARCHIMEDIPORA d'Orbigny, 1850

Remarks.—The name *Archimedes* was first published by Owen (1842, p. 19), who described it as

> . . . a very remarkable fossil coralline, resembling the *Retepora* of *Lin.*, but verticillated spirally like a continuous screw; described by *Lesueur* under the appropriate name of Archimedes.*

Owen added in the indicated footnote,

> I am not sure that Lesueur ever published his description of this fossil; . . . he considered it, I believe, a new genus; but it may be only a new species of *Retepora;* if so, most aptly entitled *Retepora Archimedes.*

An accompanying sketch is entitled "Archimedes, of Lesueur."

In 1852 Owen figured another specimen as *Retepora Archimedes*, concerning which he stated (Owen, 1852, pl. IV, figs. 1, 1a, and explanation),

> It has been known to Western geologists for many years under the name of *Archimedes.*

Regarding his 1842 paper, he went on to say that

> . . . it seemed to be a species of *Retepora* coiled in the shape of a screw.

From the above, it is evident that *Archimedes*, as a genus, was not definitely proposed by Owen (nor by Owen for Lesueur) in

[5] Correspondence, April 29, 1940.

1842, because he was not certain of Lesueur's intentions regarding it, as exemplified by Owen's statement "he considered it, I believe, a new genus; but it may be only a new species of *Retepora*." Furthermore, he definitely referred to it as *Retepora Archimedes* and his subsequent reference in the same paper to *Archimedes* must, therefore, be considered as a reference to the trivial name of *R. archimedes* Owen. Neither of these references constitutes a generic diagnosis, and the labeling of his figure of 1842 as "*Archimedes*, of Lesueur" does not establish a new genus according to the International Rules of Zoological Nomenclature, but Owen, by illustrating and naming *Retepora Archimedes*, definitely made a new species available under the rules.

In 1850, d'Orbigny (p. 102) erected the genus *Archimedipora* with the following diagnosis:

> Cellules longues, placées aux angles saillants d'une spirale autour d'une tige allongée;

as the only species under *Archimedipora*, d'Orbigny indicated

> *Archimedes*, d'Orb. *Retepora Archimedes*, Lesueur, 1842.

Here, then, is the definite naming of a new genus. D'Orbigny erred in referring the species *A. archimedes* to himself, as he quoted Owen for it. Lesueur's name is better omitted from synonymies because he did not publish his findings, nor did he furnish the published description; it is merely demonstrated that he also discovered the fossils and his *nomen nudum* was perpetuated. In 1847 Yandell and Shumard mentioned the occurrence of *Archimedes* [*sic*] in their "Contributions to the Geology of Kentucky" (p. 25), but gave no diagnosis, so this reference has no standing, either.

Hall (1856, p. 177) pointed out that d'Orbigny not only misunderstood the taxonomy and morphology of *Retepora Archimedes* Owen, but recorded it from the Devonian; therefore, Hall contended that *Archimedipora* is not valid. Hall correctly reported the facts, but his contention is not in accordance with the International Rules of Zoological Nomenclature.

The genotype of *Archimedes* was selected by Miller (1889, p. 292) as *Archimedes wortheni* Hall. *Archimedes wortheni* Hall is considered to be synonymous with *Retepora Archimedes* Owen = *Archimedes archimedes* (Owen) = *Archimedipora archimedes* (Owen). Owen's species clearly has priority, but the types are lost, in so far as the writer can determine, therefore, the writer designates as the neotypes of *Archimedipora archimedes* (Owen) the types of *Archimedes wortheni* Hall, which are in the American Museum of Natural History, type number 5058/1.

The types of the genotype species thus remain the same, but the genotype should be known as *Archimedipora archimedes* (Owen), which is the available name of the erstwhile *Archimedes wortheni* Hall.

Undesirable as it may be, the setting aside of *Archimedes* as a valid genus seems to be the only course to follow, if the rules are to be followed strictly. Should the International Commission on Zoological Nomenclature desire to make an exception in this case, then *Archimedes* may be validated; but until that time the author believes it is invalid.

Several species of *Archimedipora* from the Pitkin have the supports termed by Hall (1858, pp. 651, 652, pl. 22, fig. 3) "oblique braces," "props," and "braces." From Hall's description and figure, the oblique braces, as they may well be termed, are represented as occurring only between flanges of spiral supports. The specimens at hand have oblique braces extending away from the axis and passing through several fronds. Hall stated that the oblique braces are solid, whereas, at least some of the Pitkin specimens are hollow. The oblique braces must certainly have served as means of support, as they are located at the region where currents would develop the greatest stress upon the frond.

It is interesting that this genus also occurs in the Old World, as shown by Nikiforova (1938, p. 234), who points out that Stuckenberg discovered the genus in 1875 in the "Mountain Limestone" of Timan. Nikiforova states that the genus occupies a somewhat higher stratigraphic position in Russia than in North America, being abundant in the Upper and Middle Carboniferous of the U.S.S.R.

Material.—Oblique braces are shown on U. C. numbers 48347–48351, inclusive (see pl. 23, fig. 13).

Genus LYROPORA Hall, 1857
LYROPORA SOLIDA Easton, n. sp.
Plate 23, figures 7, 8

Zoarium with apertures on concave side of frond. Base of support not preserved. Lateral supports thickened, forming periphery of zoarium which is reflexed in holotype to form deep horseshoe-shaped notch separating lateral lobes. Thickened periphery everywhere ornamented with lirations numerous, fine, anastomosing, irregularly directed, locally extending onto 2 or 3 fenestrules of frond. Zoarium of holotype incomplete, at least 5 cm. high, 8 cm. broad.

Zooecia 23 or 24 in 5 mm., in two slightly irregular ranges, except before origin of new branch, where 3 rows extend for about 5 zooecia. Apertures subcircular, 0.08 mm. in diameter, with a peristome. Branches originate by intercalation, possibly by lateral branching; no undoubted instance of bifurcation observed. Dissepiments about 0.29 mm. wide, 16 to 18 fenestrules in 1 cm. (measured across dissepiments). Branches about 0.21 mm. wide, 24 or 25 fenestrules in 1 cm. (measured across branches). Fenestrules suboval about 0.24 mm. wide, about 0.27 mm. long, arranged in diagonal rows. Branches and dissepiments much thickened, especially at junctions, forming low nodes on reverse side; branches and dissepiments both marked near reverse surface in thin sections by striae. Hemisepta strong, occurring in almost all zooecia, located well out on floor next to reverse side. Median keel on obverse surface nearly obsolete, line of sinuous, weak elongate nodes present. One to 3 pores 0.03 to 0.04 mm. in diameter are located irregularly near the obverse surface on dissepiments; similar pores are rarely located on branches between apertures.

Comparison.—This species combines certain characters of several Chester species but is most similar to *L. quincuncialis* Hall, from which it differs chiefly in having zooecia twice as closely spaced. It is similar to *L. ovalis* Ulrich in having the apertures on the concave surface, but differs in having more than 10 fenestrules in 1 cm. The species can be distinguihsed from *L. ranosculum* Ulrich and *L. subquadrans* Hall by its two ranges of apertures on the branches, rather than more. Though similar to *L. divergens* Ulrich in possessing peristomes, this species differs in having more than 12 or 13 fenestrules in 1 cm. Details of the obverse surface were observed from thin sections, as that surface is buried in the matrix of the specimens studied.

Types.—Holotype, U. C. 47201; paratype, U. C. 47204; both from locality 37.

Family CYSTODICTYONIDAE
Genus DICHOTRYPA Ulrich, 1890
DICHOTRYPA LEVIS Easton, n. sp.
Plate 23, figures 9, 10

Zoarium a broadly wrinkled bifoliate expansion 1 to 2 mm. thick. Dimensions and zoarial margin unknown. Surface marked by strong, solid, elongate maculae, depressed, or with rim of slightly raised zooecia. Maculae smooth, about 1.7 to 1.8 mm. long, about 0.8 mm. wide, centers separated 2 to 4 mm. measured across breadth, 4 to 5 mm. along length. Apertures usually irregularly spaced, locally occurring in diagonal rows, about 9 or 10 apertures in 3 mm. spaced about their own diameter apart.

Tangential section.—Zooecia compressed-oval, about 0.12 mm. wide, about 0.17 mm. long, arranged with greatest dimensions roughly parallel. Lunaria poorly preserved or degenerate, commonly with one termination forming short projection into zooecia. Interspaces granular in shallow sections with occasional vesicles faintly showing.

Longitudinal section.—Median lamina strong, rather straight, with a deposit of secondary material on both sides. Zooecia prostrate from origin to about one-third to one-half their length, then swinging abruptly toward surface; near surface recurved toward origin. Zooecial walls strongest near origins, later less well defined. Dissepiments one or possibly two, thin, may occur near abrupt change in direction of zooecia. Interspaces most vesicular near median lamina, with granular sclerenchyme distributed irregularly. Superior hemisepta, when preserved, moderately strong.

Comparison.—This species differs from *D. elegans* Ulrich in having more closely spaced irregularly arranged apertures and without either circular or substellate maculae. It differs from *D. flabellum* Rominger in having

no substellate maculae, more closely spaced apertures and smooth maculae.

Type.—Holotype, U.S.G.S. 5198 from locality 1388 blue.

Genus GLYPTOPORA Ulrich, 1888
GLYPTOPORA CRASSA Easton, n. sp.
Plate 23, figures 11, 12

Zoarium bifoliate expansions 1 to 2 mm. thick, forming cup-like structures by coalescence; generally leaf-like, broadly wrinkled. Surface marked by depressed maculae or "dimples," commonly widest near one end, arranged with long axes sub-parallel. Rows of about 6 slightly elevated zooecia line each side of the maculae, may form horse-shoe-shaped rows of about 13 zooecia almost encircling maculae. Maculae 2 to 3 mm. long, 1 to 1.5 mm. wide, irregularly spaced, about 5 mm. between centers in direction of long axes, somewhat closer in other direction. Zooecia reniform, in diagonal rows, 13 apertures in 5 mm.

Tangential section.—Zooecia rather thick-walled, 0.20 mm. in average diameter. Lunaria fairly distinct in shallow sections, showing as two small angular extensions of slight swelling always located on same side of zooecia. Vesicles small, irregular, generally in 2 or more rows between zooecia. Maculae appear as undifferentiated material.

Longitudinal section.—Zooecia prostrate upon mesotheca, turn up sharply, reach surface at nearly right angles. Hemisepta and diaphragms 1 or 2, near origins of some zooecia. Vesicles small, irregularly placed. Mesotheca thin, covered on both sides with sclerenchyme. Row of very large semicircular vesicles adjacent to mesotheca, contains 1 to 4 sharp-pointed extensions from mesothecal sclerenchyme. Many large vesicles thicken and strengthen region in angles between ramifications of zooecial expansions. Maculae formed of closely packed vesicles with one row of larger vesicles next to mesotheca.

Comparison.—This species differs from *G. keyserlingi* Prout in having thicker fronds, smaller and unstriated maculae, and slightly larger zooecial apertures.

Types.—Holotype, U. C. 48199; paratype, U. C. 48200; both from locality 6.

Class BRACHIOPODA
Subclass INARTICULATA
Order NEOTREMATA
Family CRANIIDAE
Genus CRANIA Retzius, 1781
CRANIA INFIMBRIATA Easton, n. sp.
Plate 24, figure 11

Shell subcircular, length of holotype 1.3 cm. Most specimens measure about 1 cm. across.

Pedicle valve attached, also possibly free. Interior not observed.

Brachial valve, commonly very low, conical or almost flat, may be convex in seemingly unattached specimens. Apex excentrically located, either depressed or acutely erect. Margin of valve overlaps pedicle valve, outline lobate in some specimens. Greatest depth of holotype about 2 mm. at apex. In specimen attached to exterior of a *Spirifer*, shell assumes general contour of latter, but its costae are not reflected. Surfaces of some specimens bear irregular, usually rugose, concentric growth marks most commonly near margin. Interior of one valve exposed, but not preserved sufficiently well to permit description of muscle scars.

Comparison.—This species is variable but can be distinguished readily from the only other described Chester species, *Crania chesterensis* Miller and Gurley, by the absence of the pronounced thickened marginal lip of the brachial valve. It differs from other species of *Crania* either in the absence of radiating costae or in the presence of coarse concentric markings.

Types.—Holotype, U.S.G.S. 5199; paratypes, U.S.G.S. 5200; all from locality 1388 blue.

Subclass ARTICULATA
Order PROTREMATA
Family STROPHOMENIDAE
Genus ORTHOTETES Fischer, 1830
ORTHOTETES SUSPECTUM (Girty)

Streptorhynchus suspectum GIRTY, *1929*, Jour. Washington Acad. Sci., vol. 19, no. 7, p. 136, figs. 12–15.

Remarks.—The presence of a well-defined median septum in the pedicle valve of this species reveals, that it is an *Orthotetes*. There is evidence that Girty discovered this fact subsequent to his original description.

ORTHOTETES KASKASKIENSIS
McChesney var.

Orthotetes kaskaskiensis WELLER, *1914*, Illinois Geol. Survey, Monograph 1, p. 77, pl. 6, fig. 15.

Remarks.—Stuart Weller figured a specimen of *Orthotetes kaskaskiensis* which differs from the typical specimens in that there are 4 fine costae between larger costae. A fragment of such a shell is in the Pitkin collections and compares precisely with the specimen Weller figured in every feature except size. It may be that this is a consistent variation, or perhaps it is merely an environmental variation. In modern oceans, shells of the pelecypod *Pecten* become coarsely ribbed when the animal lives in agitated water, whereas the same species may be smooth or nearly so in quieter water. Here then, may be an index to the ecology of the sea in which this species lived, for the specimen from the Pitkin came from a shaly limestone, rather than the dominant limestone phase. Other Pitkin specimens of the same species collected from the pure limestone strata have costae of equal strength.

Material.—U.C. 48329; locality 25.

Family PRODUCTIDAE
Genus CHONETES Fischer, 1837
CHONETES TUMESCENS Easton, n. sp.
Plate 24, figures 1–5

Shell concavo-convex to biconvex, curvature quite variable, length about two-thirds width, greatest width midway between cardinal area and anterior margin. Cardinal extremities angular, only slightly concave in front of cardinal extremities, rather evenly convex curvature continuing around anterior margin, although somewhat straightened in some specimens. Median sinus obsolete.

Pedicle valve flatly convex, greatest convexity just posterior to middle, surface curving abruptly anterior to middle, sloping flatly from beak to cardinal extremities. Beak minute, definitely extended beyond cardinal margin, marked by two short fine costae. Cardinal area flat, straight, longitudinally striated, tilted outwards somewhat, forming angle of about 100 degrees with surface of valve. Eight (in some cases, 7) hollow spines directed outwardly and laterally from each side of beak. Edges of delthyrium form angle of about 90 degrees; deltidium outwardly produced hood-like structure. Inner surface valve finely papillose bordering muscle scars, marginally more coarsely marked; short median septum separates muscle scars.

Brachial valve moderately concave to slightly convex, sloping to cardinal extremities. Cardinal area flat, longitudinally striated, about as wide as that of opposite valve, the two forming an angle of about 170 degrees. Cardinal process nearly filling delthyrium of opposite valve, bearing 6, coarse, radially arranged costae, median pair strongest. Cardinal process surmounted ventrally by 2 squat lobes, anteriorly by 2 very small swellings; very heavy rounded ridge extends laterally from each side of the cardinal process about one and one-half times width of cardinal process, forms angle of about 30 degrees with margin of cardinal area. Pair of delicate ridges with ventral extremities directed medianly diverge anteriorly from cardinal process at angle of about 55 degrees extend distance equal to width of cardinal process. Low median ridge extends directly anteriorly 3 times width of cardinal process. Interior of the valve finely papillose, except at muscle scars where it is smooth.

DIMENSIONS OF CHONETES TUMESCENS

	Length of valves		Width of valves		Greatest Width	Convexity
	Brachial	Pedicle	Brachial	Pedicle		
Holotype	11.0 mm.	11.2 mm.	13.9 mm.	14.2 mm.	15.1 mm.	2.4 mm.
Paratype 1	12.4	12.7	15.0	15.6	16.9	—
Paratype 2	11.3	11.6	16.0	16.2	17.8	2.2
Paratype 3	10.9	11.1	—	—	15.0	2.1
Paratype 4	11.5	12.3	15.9	16.3	16.6	2.2

Surfaces of both valves marked by fine radiating lirae developed either by bifurcation or intercalation, about 150 around margin of shell, 5 to 8 in 1 mm., finest posteriorly, wider than intervening furrows, absent only in long narrow triangular region on each side of beak and bordering cardinal area. Concentric growth lines well developed. Pits between lirae and growth lines about 4 in 1 mm., more or less regularly arranged.

Comparison.—This species is closely allied to *Chonetes chesterensis* Weller, but differs in having a less concave brachial valve, more spines on each side of beak, cardinal areas of about the same width on each valve, and it commonly attains larger size. It differs from *C. oklahomensis* Snider in having flatly sloping rather than recurved auricular extremities, a less concave brachial valve and a straight cardinal area that is flat rather than arcuate.

Types.—Holotype, U.C. 48296; paratype, U.C. 48297; both from locality 30.

Genus ECHINOCONCHUS Weller, 1914
ECHINOCONCHUS ? sp.

Remarks.—A small productid of unusual nature is tentatively referred to this genus at the suggestion of A. H. Sutton. The width of the shell is three-quarters the greatest length and the convexity is about half the greatest length. Concentric markings are restricted to the anterior portion of the shell and each band has more than one row of spinules. Although these characters are typical of *Echinoconchus*, the bands do not begin near the beak, the proportions of the shell are different, and the beak is more recurved than in that genus.

Material.—U.C. 48254; locality 25.

Genus KROTOVIA Fredericks, 1928
KROTOVIA LUCERNA Easton, n. sp.
Plate 24, figures 6–8

Shell broadly convex, flattened umbonally, evenly sloping to anterior margin, very steeply sloping to ears. Beak sharply rounded, recurved, extending 3 mm. beyond hinge line. Two specimens measure: lengths, 15.5 mm. and 12.5 mm.; widths, 14.3 mm. and 14.0 mm.; convexities, 6.5 mm. and 6.5 mm.; lengths of hinges, 12.0 mm. (restored) and 9.3 mm.

Pedicle valve of holotype small, subhemispherical, about as long as wide, one-fourth as high as long. Hinge line about three-quarters length of shell. Ears small, recurved ventrally, marked off by a sharp sulcus on each lateral slope. Cardinal extremities slightly anteriorly directed, rounded. Lateral margins evenly curved, not separated from anterior margin by differences in radii of curvatures except near hinge line where curvature is more abrupt. Highest point of curvature of ventral surface of shell just anterior of midlength. Median sinus faint or absent. Interior not seen.

Brachial valve not definitely identified.

Surface ornamented by numerous fine, subequal spinules reflexed upon surface, covering entire valve, somewhat finer on beak than elsewhere. On anterior slope spinules somewhat longitudinally arranged. Varices of growth few, irregularly spaced closest on lateral slopes and ears.

Comparison.—This species differs from *K. meeki* Dunbar and Condra in the smaller size, more pointed and narrower umbonal area, and more elongate spinules. It differs from *Pustula echinata* Moore in the larger spinules, more elongate umbo, and lower convexity.

Types.—Holotype, U.C. 48253 from locality 29; ideotype U.C. 48255 from locality 15; ideotype U.C. 48342 from locality 42.

Remarks.—According to A. H. Sutton[6] *P. echinata* should be referred to *Krotovia*. If so, *K. lucerna* is the second species of the genus reported from the Mississippian of this country, and the third from our Carboniferous.

Genus PRODUCTUS Sowerby, 1812
PRODUCTUS CESTRIENSIS Worthen

Productus elegans NORWOOD AND PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour. Ser. 2, vol. 3, p. 3, pl. 1, figs. 7a–c. Not *Productus elegans* McCOY, *1844*.

Productus cestriensis WORTHEN, *1860*, St. Louis Acad. Sci., Trans., vol. 1, pp. 570, 571.

Productus elegans, SUTTON, *1938*, Jour. Paleontology, vol. 12, no. 6, pp. 599, 567, pl. 64, figs. 9–12.

Remarks.—The above selected synonymy lists the first reference to the species, the

[6] Correspondence, April 15, 1940.

reference to the available name, and the latest reference (which contains a long synonymy). Worthen found *Productus elegans* Norwood and Pratten to be a homonym of *Producta elegans* M'Coy, 1844, ("*Leptaena elegans*" on plate), and selected the name *P. cestriensis* to replace it. Most subsequent workers have disregarded Worthen's action, as well as Articles 35 and 36 of the International Rules of Zoological Nomenclature. The fact that the species was once referred to *Diaphragmus* has no bearing on the case.

Genus LINOPRODUCTUS Chao, 1927

LINOPRODUCTUS PILEIFORMIS (McChesney)

Productus ovatus HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, fig. 1. Not *Productus ovatus* PANDER *1830*.

Productus pileiformis MCCHESNEY, *1859*, Descriptions New Paleozoic Fossils, p. 40.

Linoproductus ovatus, SUTTON, *1938*, Jour. Paleontology, vol. 12, no. 6, p. 558, pl. 65, figs. 8–13.

Remarks.—This case of a rejected homonym is similar to the last, the name being preoccupied by *P. ovatus* of Pander (1830, p. 86, pl. 27, figs. 13a, b). It is noted in an unfinished manuscript by G. H. Girty.

Order TELOTREMATA

Family SPIRIFERIDAE

Genus SYRINGOTHYRIS Winchell, 1863

SYRINGOTHYRIS AEQUALIS Easton, n. sp.

Plate 24, figures 12–14

Shell large, half again as wide as long, greatest width of brachial valve between cardinal extremities 5 cm. in one specimen, greatest length medially 2.7 cm. Length of pedicle valve of holotype 23 mm. from beak to anterior margin; height of cardinal area 17.5 mm.; width of cardinal area 38 mm.; width of delthyrium at base 12 mm.; width of anterior portion of sinus about 10 or 11 mm.

Pedicle valve sharply pyramidal, anterior slope somewhat convex near beak but nearly straight for last three-quarters of length; lateral slopes slightly concave from umbo to cardinal extremities. Median sinus broad, shallow, without plications, originating as sharp depression at beak, extending about 2.5 mm. beyond anterior margins of sides. Cardinal area very high, inclined almost 90 degrees to the plane of valves, marked by broad but strong concentric markings parallel to hinge line; depth of curvature along lateral slopes about 1 mm. in 25 mm. Beak slightly produced posteriorly. Lateral margins 12 or 13 mm. wide at hinge line. Delthyrium two-thirds as wide as high; delthyrial plate depressed 1.5 to 2 mm. below cardinal area, bordered by groove extending full length of the delthyrium; delthyrial plate sharply concave on each side of very strong external median rib which extends nearly 9 mm. down from beak. Dental lamellae not observed.

Brachial valve with broad, low, unplicate fold originating at recurved beak; fold highest at anterior end, producing emargination. Greatest depth of valve posterior to mid-length. Greatest convexity along median portion near hinge line, flatter toward cardinal extremities. Angle between hinge line and lateral margins nearly 90 degrees. Muscle scars divided by median septum showing

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EXPLANATION OF PLATE 23

FIGS. *1, 2—Tabulipora poculoformis*, n. sp. *1*, longitudinal section, ×20; *2*, tangential section, ×20; U. C. 48182, holotype. (p. 141)

3, 4—Tabulipora reflexa, n. sp. *3*, tangential section, ×20; *4*, longitudinal section, ×20; U. C. 48191, holotype. (p. 141)

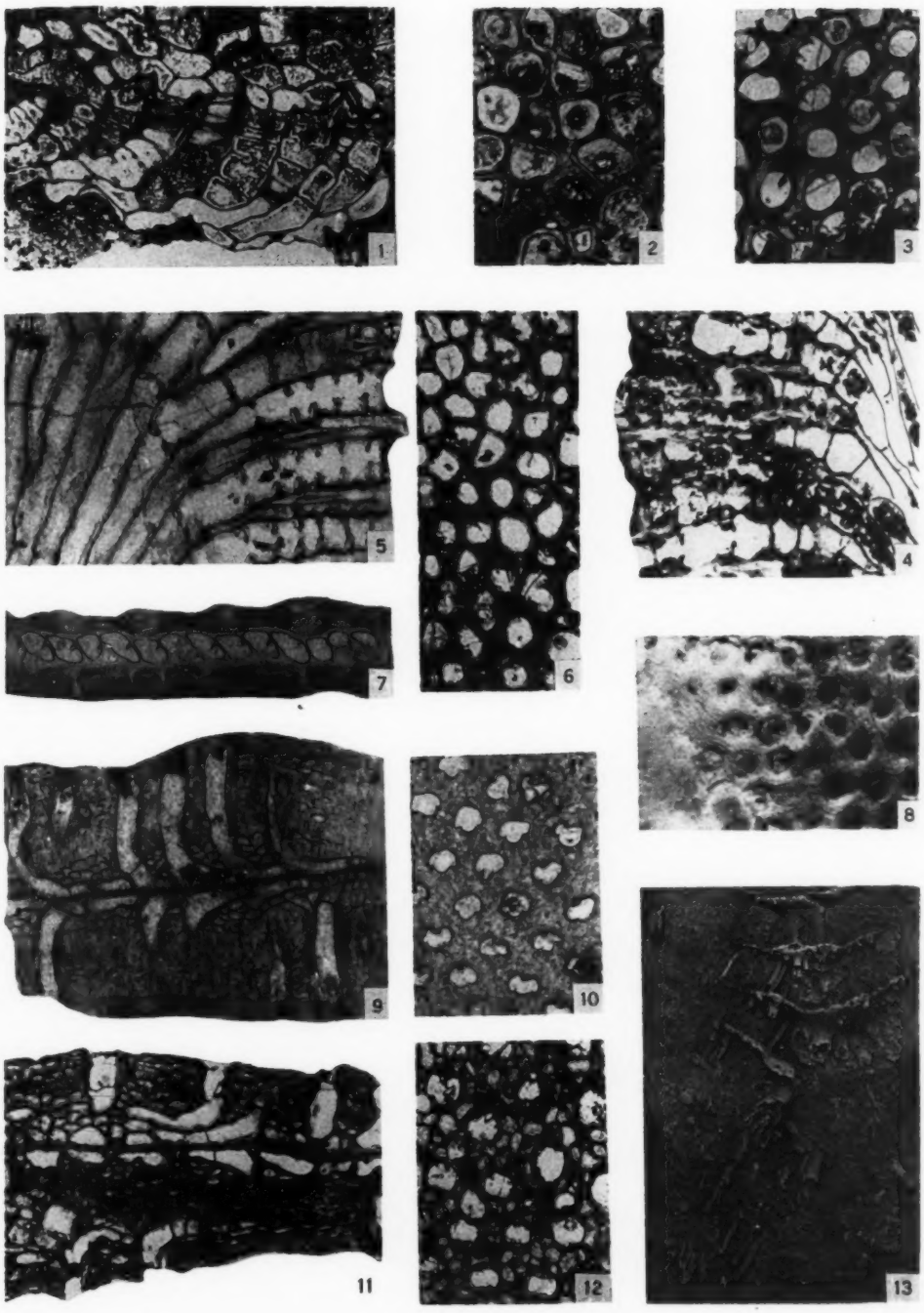
5, 6—Tabulipora subtilis, n. sp. *5*, longitudinal section, ×20; *6*, tangential section, ×20; U. C. 48180, holotype. (p. 142)

7, 8—Lyropora solida, n. sp. *7*, vertical section through one side of branch, showing hemisepta, ×20; U. C. 47201, holotype. *8*, reverse side of part of frond showing minute wrinkles on solid border, ×10; U. C. 47204, paratype. (p. 144)

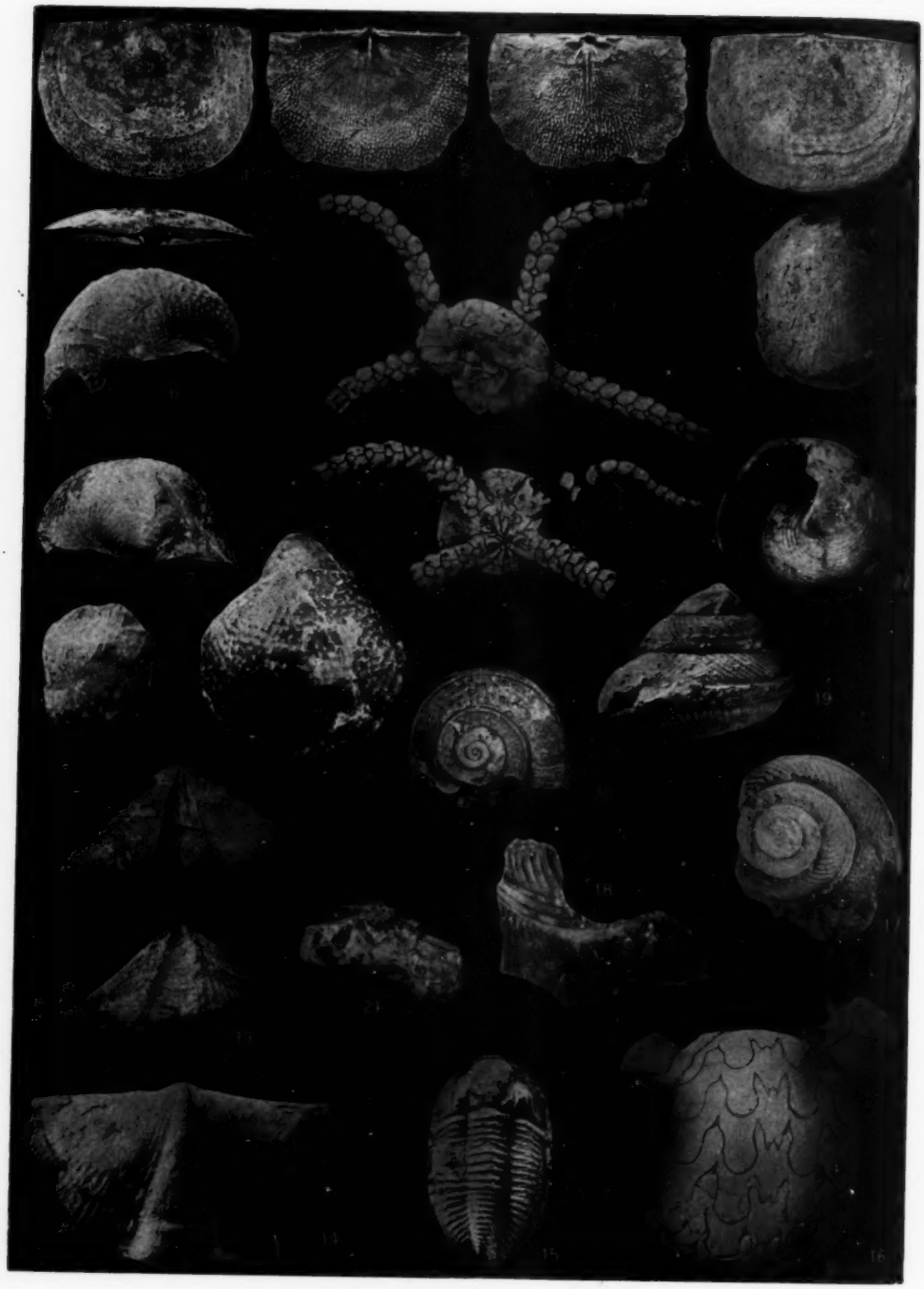
9, 10—Dichotrypa levis, n. sp. *9*, longitudinal section, ×20; *10*, shallow tangential section showing dense sclerenchyme, ×20; U.S.G.S. 5198, holotype. (p. 144)

11, 12—Glyptopora crassa, n. sp. *11*, longitudinal section, ×20; *12*, tangential section, ×20; U. C. 48199, holotype. (p. 145)

13—Archimedipora sp., showing oblique braces, ×1; U. C. 48347. (p. 143)



Easton, Pitkin Fauna



Easton, Pitkin Fauna

through shell substance for two-thirds of length of valve.

Surface of pedicle valve with 21 to 23 unbranching plications on lateral slopes; plications increasingly rugged anteriorally, parallel to sinus, laterally inclined, becoming nearly parallel to cardinal margin; stronger plications originate near beak, progressively weaker plications originate along cardinal margins. Broad concentric markings present. Lateral margins plicate on brachial as on pedicle valve, but concentric markings somewhat stronger.

The pedicle valve of a very young specimen shows quite rounded cardinal margins, a slightly concave cardinal area, an incurved beak, a well developed slightly produced sinus with re-entrant angles on each side at the junction with the lateral margins, 10 plications, and rounded lateral cardinal areas. This valve is 8.5 mm. wide, 5 mm. long, and the cardinal area is 3.7 mm. high.

Comparison.—This species can be distinguished from *S. hannibalensis* (Swallow) by the shallower and less produced sinus. It differs from *S. newarkensis* Weller by the width of each cardinal margin being nearly equal to the width of the delthyrium. In one large crushed specimen the height of the cardinal area is 30 mm. and the greatest width of the delthyrium is 20 mm.

Types.—Holotype, U.S.G.S. 5201; paratypes, U.S.G.S. 5202; all from locality 1379 blue.

Phylum MOLLUSCA
Class PELECYPODA
Order PRIONODESMACEA
Family AVICULOPECTINIDAE
Genus AVICULOPECTEN McCoy, 1851, emend. Newell, 1937

AVICULOPECTEN BATESVILLENSIS Weller

Aviculopecten batesvillensis WELLER, *1897*, Trans., New York Acad. Sci., vol. 16, p. 263, pl. 19, figs. 3, 4.
Aviculopecten batesvillensis, WELLER, *1898*, U. S. Geol. Surv. Bull., 153, p. 107.
Deltopecten batesvillensis, GIRTY, *1911*, U. S. Geol. Surv., Bull. 439, p. 89, pl. 11, figs. 1–4
Deltopecten batesvillensis, SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pp. 42, 108, chart facing p. 66.
Deltopecten batesvillensis?, GIRTY in REGER, *1926*, West Virginia Geol. Survey, p. 853.
Deltopecten batesvillensis, ROTH, *1929*, Oklahoma Geol. Survey,Circ. 18, chart facing p. 16.
Deltopecten batesvillensis, CRONEIS, *1930*, Arkansas Geol. Survey, Bull. 3, pp. 54, 55, 62–64, 71, 75, pl. 13, fig. 20, pl. 15, fig. 13.
Deltopecten batesvillensis, MORSE, *1930*, Mississippi Geol. Survey, Bull. 23, pp. 170, 184.

Remarks.—Newell (1937, p. 64) has shown that the characters separating *Deltopecten* from *Aviculopecten* do not exist in most Carboniferous forms, and that the former genus is confined to the Middle and Upper

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EXPLANATION OF PLATE 24

FIGS. *1–5—Chonetes tumescens*, n. sp. *1*, exterior of pedicle valve, ×2; *2*, interior of pedicle valve, ×2; *3*, interior of brachial valve, ×2; *4*, exterior of brachial valve, ×2. *5*, posterior view of shell, ×2. Figs. *1*, *4*, *5*, U. C. 48296, holotype; figs. *2*, *3*, U. C. 48297, paratype. (p. 146)
6–8—Krotavia lucerna, n. sp. *6*, lateral view of pedicle valve, ×2; U. C. 48342, ideotype; *7*, posterior view of pedicle valve, ×2; *8*, dorsal view of pedicle valve, ×2; U. C. 48253, holotype. (p. 147)
9, *10—Aganaster cingulatus*, n. sp. *9*, dorsal view, ×6, paratype; *10*, ventral view, ×6, holotype; all on one slab, U. C. 48291. (p. 137)
11—Crania infimbriata, n. sp. Brachial valve, ×2; U. S. G. S. 5199, holotype. (p. 145)
12–14—Syringothyris aequalis, n. sp. *12*, posterior view of pedicle valve, ×1; *13*, anterior view of pedicle valve, ×1; U.S.G.S. 5201, holotype. *14*, ventral view of brachial valve, ×1; U.S.G.S. 5202, paratype. (p. 148)
15—Paladin mucronatus (Girty). Carapace, ×1, U. C. 48313. (p. 152)
16—Eoasianites globosus, n. sp. Adoral view, ×2, U. C. 48192, holotype. (p. 152)
17–19—Mourlonia angulata, n. sp. *17*, apical view, ×5; *18*, lateral view, ×5; U.S.G.S. 5203, holotype. *19*, lateral view of part of two whorls showing color markings, ×5; U.S.G.S. 5204, paratype. (p. 150)
20, *21—Straparolus triliris*, n. sp. *20*, apical view, ×2; *21*, lateral view, ×2; U. C. 48304, holotype. (p. 151)
22—Euphemites incarinatus, n. sp. Lateral view, ×2; U. C. 48325, holotype. (p. 150)
23—Helcionopsis? reticulatus, n. sp. Exterior, ×1; U. C. 47202, holotype. (p. 150)

Permian of the Eastern Hemisphere. This species must, therefore, be returned to its original genus.

Class GASTROPODA
Subclass STREPTONEURA
Order ASPIDOBRANCHIA
Suborder DOCOGLOSSA
Family PALAEACMAEIDAE
Genus HELCIONOPSIS Ulrich and Scofield, 1897
HELCIONOPSIS? RETICULATUS Easton, n. sp.
Plate 24, figure 23

Shell subcircular, patelliform, anterior end truncated slightly obliquely to greatest (anterior-posterior) diameter. Shell broken away from beak of monotype, but internal cast approximately determines shell margin at produced beak. Beak located to one side of center line. Surface ornamented by two sets of obliquely intersecting markings forming reticulated pattern; numerous closely spaced fine costae near center line have coarser counterparts more widely spaced on lateral slope toward which beak is deflected (coarser markings may have counterparts on other slope, but they are not apparent). Second set of markings, nearly equally spaced, subparallel, intersect the costae obliquely, cross shell from anterior-lateral margin to opposite or posteriolateral margin toward which beak is deflected. Internal structure unknown. Dimensions: greatest length 26 mm., greatest breadth, 24 mm., greatest depth midway posteriorly from beak 7.5 mm.

Comparison.—The unique sculpturing alone is sufficient to differentiate this species from described species of either *Helcionopsis* or *Triblidium*. Although this species may represent a new genus, the nature of the muscle scars cannot be determined from the material at hand.

Type.—Holotype, U.C. 47202; locality 37.

Family BELLEROPHONTIDAE
Genus EUPHEMITES Warthin, 1930
EUPHEMITES INCARINATUS Easton, n. sp.
Plate 24, figure 22

Shell small, involute, discoidal to subglobose in ephebic stages; dimensions of two specimens greatest diameters, 8.2 mm. and 4.9 mm.; greatest widths of body whorls, 8.9 mm. and 5.2 mm. Aperture reniform, width twice length (in the plane of coiling). No prominent geniculation present in shell curvature. Body whorl recurved near umbilical regions, somewhat flared, not revolving. Whorl section acutely lunate posteriorly from aperture. Inner lip seemingly formed by surface of preceding whorl in most cases, without callosity; rare instances of seeming callosities may be result of mineralization. Umbilical regions not excavated, partly enclosed by recurved lateral extremities of body whorl. Surface finely but sharply lirate, about 40 principal lirae with much finer intercalated lirae near edge of aperture; faint transverse growth lines intersect lirae, effect reticulate pattern with concave interstices; fine details most pronounced on the body whorl, which is commonly broken away. About 30 lirations, strongest near plane of coiling, comprise ornamentation of next-to-last whorl. No slit observed, shell not carinate where the slit-band should be located.

Comparisons.—This species differs from *E. nodocarinatus* (Hall) and *E. inspeciosus* (White) in the smaller size, more discoidal shape, noncarinate volutions, nearly centrally located umbilicus, and deeply-impressed lunate whorl-section. There is considerable variation in shell shapes, but these comprise a series, rather than different species.

Types.—Holotype, U.C. 48325; paratypes, U.C. 48326; all from locality 35.

Suborder RHIPIDOGLOSSA
Family PLEUROTOMARIIDAE
Genus MOURLONIA Koninck, 1883
MOURLONIA ANGULATA Easton, n. sp.
Plate 24, figures 17–19

Shell small, turbiniform; spire straight-sided. Whorl profile above selenizone broadly convex. Selenizone slightly concave bounded by costae. Whorl profile below selenizone very sharply rounded above, broadly convex below, rather sharply rounded at umbilical shoulders. Nucleus apparently unornamented. Surface covered with well-defined oblique costae, about 8 in 1.0 mm., above selenizone slightly convex forward, below selenizone passing backward less obliquely,

swinging forward slightly to umbilical shoulders where reversal begins; thus, costae external to umbilical shoulder and below selenizone are convex backward but at smaller angle than above. Lunulae not clearly observed. Very fine revolving lirae present between selenizone and umbilical shoulders. Exceptionally, even finer lirae are preserved between selenizone and suture. Dark zig-zag color markings between suture and selenizone, directed backward more obliquely than costae, possess 2 sharply *V*-shaped backward angles in middle; repeated about every third or fourth costa; at periphery of whorl pass into irregular splotches.

	A	B
Number of whorls	4.5	4
Height	4.0	2.6
Width	4.8	3.2
Ratio of height to width	.83	.81
Ratio of height of body whorl to total height	1.82	1.86
Pleural angle	68°	71°

Comparison.—This species differs from *M. minuta* Weller chiefly in having a generally angular, rather than a rounded whorl profile, and in having ornamentation upon the portion of the whorl between the suture and selenizone.

Types.—Holotype, U.S.G.S. 5203, locality 1388 blue; paratype, U.S.G.S. 5204, locality 1388 blue; ideotypes, U.S.G.S. 5205, locality 1389 blue.

Remarks.—The holotype (A above) is nearly anomphalous, therefore, is about mature, as Knight (1941, p. 201) has pointed out that the members of this genus are phaneromphalous in the young stages but become anomphalous at the beginning of the mature stage. The measured paratype (B above) is juvenile, whereas, the two other paratypes, though mature, are incomplete.

Family EUOMPHALIDAE
Genus STRAPAROLUS Montfort, 1810
STRAPAROLUS TRILIRIS Easton, n. sp.
Plate 24, figures 20, 21

Shell subturbinate, portion of apex including only nucleus depressed, four and one-half whorls present. Greatest diameter, 12.5 mm.; height, 7 mm.; width of aperture, 3.3 mm.; height, 4.0 mm. Nucleus rounded, unornamented; later whorls angular at upper shoulder, slightly nodose at aperture. Upper portion of body whorl flattened from suture to shoulder; lateral slope almost vertical, concave band present just below angulation of shoulder, whorl expanding laterally below; under surface of whorl evenly rounded. Umbilicus broad, probably steep-walled and deep, partially filled in holotype. Surface ornamented chiefly by transverse axial lirae, very slightly inclined posteriorly on body whorl; on spire less well defined, nearly transverse. Three ill-defined revolving ridges present on upper surface of body whorl within 2 mm. of aperture, apparently terminating in nodes.

Comparison.—This species differs from *S. umbilicatus* (Meek and Worthen) in the less depressed spire, the flatness of upper surface of lower whorls which extends farther laterally, and the vertical slopes of the whorls. It can be distinguished from many species of *Straparolus* by its turbinate form.

Type.—Holotype, U.C. 40304; locality 5.

Class CEPHALOPODA
Order NAUTILOIDEA
Suborder CYRTOCHOANITES
Genus DOLORTHOCERAS Miller, 1931
DOLORTHOCERAS ? EUREKENSIS (Walcott)

Orthoceras Eurekensis WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 265, pl. 23, figs. 2, 2a.
Orthoceras eurekensis?, WELLER, *1897*, Trans., New York Acad. Sci., vol. 16, p. 270, pl. 20, figs. 3, 3a.
Orthoceras eurekensis, WELLER, *1898*, U. S. Geol. Survey, Bull. 153, p. 395.
Orthoceras eurekensis, SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pp. 34, 39, 43, 118, 119, chart opp. p. 66.
Orthoceras eurekensis, ROTH, *1929*, Oklahoma Geol. Survey, Circ. 18, chart facing p. 16.
Orthoceras eurekensis, CRONEIS, *1930*, Arkansas Geol. Survey, Bull. 3, pp. 64, 76.

Remarks.—The orthoceraconic cephalopods from the Pitkin are provisionally placed in *Dolorthoceras*, except for those with the annulations characteristic of *Cycloceras*, and for one representative of *Mooreoceras* identified by Moore (1940, p. 415).

Suborder ORTHOCHOANITES
Genus COLOCERAS Hyatt, 1893
COLOCERAS sp.

Remarks.—Snider referred two specimens to *Leuroceras*, which, together with an addi-

tional specimen, the writer is referring to *Coloceras* sp. at the suggestion of A. K. Miller.[7] *Leuroceras* can be distinguished from *Coloceras* by the sinuous sutures in the former genus and the nearly straight sutures in the latter.

Order AMMONOIDEA
Suborder EXTRASIPHONATA
Genus EOASIANITES Ružencev, 1933
EOASIANITES GLOBOSUS Easton, n. sp.
Plate 24, figure 16

Conch subglobular, maximum diameter of phragmacone at least 18 mm.; height of last whorl 7.8 mm.; width of umbilicus about 8 mm.; width of last whorl about 20 mm.; impressed zone 2.8 mm. deep. Whorls rather depressed dorsoventrally, ventral surface evenly rounded, nearly hemispherical in cross section. Umbilical slopes sharply rounded, diameter of umbilicus slightly less than half the greatest dimension of phragmacone. In reniform aperture is small central sinus, small lateral crest, another small sinus, finally large crest at umbilical slope. Shape of aperture cannot be determined in detail because of lack of growth lines.

FIG. 1—Diagrammatic representation of a suture of *Eoasianites globosus*, n. sp., ×3.5.

Test thin, unornamented. Internal mold exhibits shallow concave constrictions directed medianly and anteriorly, strong lateral portions of which would meet at angle of 120 degrees if extended across obsolete median portion of constriction; probably fewer than 3 constrictions in one volution.

Sutures shown on holotype nearly identical, except for size. Each suture possesses short, sharply bifid, median saddle within more prominently bifid ventral lobe; first lateral saddle broadly spatulate; first lateral lobe asymmetrically lanceolate, curving up least broadly on lateral side; second lateral saddle broadly curved but depressed just lateral to summit, curving sharply over umbilical slope; second lateral internal saddle flattened, broad; first lateral internal lobe elongate, swollen laterally about midway but sharply acuminate at termination; other sutural characters not shown. Second lateral external saddle broadest, first lateral lobes narrowest (except for bifurcations of external lobe), subequal.

Comparison.—This species is closely allied to *E. oblatus* (Miller and Moore) from the Morrow group, but differs in its somewhat smaller size, more globular shape, more rounded surface of whorls, *V*-shaped transverse constrictions, and minor differences in sutural expression.

Type.—Holotype, U.C. 48192; locality 16.

Phylum ARTHROPODA
Class CRUSTACEA
Subclass TRILOBITA
Order OPISTHOPARIA
Family PROETIDAE
Genus PALADIN Weller, 1936
PALADIN MUCRONATUS (Girty)
Plate 24, figure 15

Griffithides mucronatus GIRTY, *1910*, Ann., New York Acad. Sci., vol. 20, no. 3, pt. 2, p. 238.
Griffithides mucronatus, GIRTY, *1915*, U. S. Geol. Survey Bull. 593, pp. 14, 133, 134.
Griffithides mucronatus, PURDUE AND MISER, *1916*, U. S. Geol. Survey, Folio 202, pp. 12, 13.
Griffithides mucronatus, ROTH, *1929*, Oklahoma. Geol. Survey, Circ. 18, chart facing p. 16.
Griffithides mucronatus, CRONEIS, *1930*, Arkansas Geol. Survey, Bull. 3, pp. 63, 65, 71, 72, 75.
Paladin mucronatus, WELLER, *1936*, Jour. Paleontology, vol. 10, no. 8, p. 707.

Remarks.—More than 150 trilobite specimens (mostly incomplete) are referable either to this species or to *Kaskia chesterensis* J. M. Weller. Although a diligent search was made for specimens referable either to *Griffithides* sp. or to *G. pustulosus* Snider (both previously reported from the Pitkin), nothing typical of these forms has been seen. References in synonymies, therefore, can scarcely contain proper listing of these doubtful reports, because their true identity cannot be established at present.

[7] Correspondence, April 15, 1940.

LOCALITY LIST

3. Shale and argillaceous limestone in reentrant near top of Pitkin on south side of outlier in NW¼ sec. 35, T. 16 N., R. 30 W.
4. Massive ledge of limestone at top of Pitkin Bluff on east side of Fayetteville Country Club, 300 yards south of clubhouse.
5. Coarsely crystalline limestone from which spring flows across highway, due west of quarry at Cane Hill, Arkansas.
6. Very impure limestone and shale in small quarry on downthrow side of fault in road cut on hill 0.52 mile east of postoffice at Leslie, Arkansas.
7. Impure limestone under rock shelter at bluffs above Highway 71, ¾ mile southeast of West Fork, Arkansas.
8. Near top of Pitkin on north side of valley, ¼ mile east of road, 1 mile south of Cane Hill, Arkansas, in SE¼ sec. 8, T. 14 N., R. 32 W.
10. Nodular limestone 24 inches thick, with shale near base of Pitkin in bluff north of road at gully near foot of hill northeast of Limestone, Arkansas, in NW¼ sec. 8, T. 14 N., R. 21 W.
15. Upper impure limestone bed at bluffs above Highway 71, ¾ mile southeast of West Fork, Arkansas.
16. Near top of coarse crystalline limestone at top of Pitkin in quarry at Cane Hill, Arkansas.
17. Black shale layer one-half inch thick in lower part of Pitkin in quarry at Cane Hill, Arkansas.
20. Near top of Pitkin in SE¼ sec. 8, T. 14 N., R. 32 W.
23. Upper part of Pitkin at small dry creek 2 miles east of Watts, Arkansas.
24. Limestone flat on east bank of War Eagle Creek, 100 yards south of bridge south of Huntsville in SE¼ NW¼ sec. 23, T. 16 N., R. 26 W.
25. Middle of Pitkin in bluffs above Highway 71, ¾ mile southeast of West Fork, Arkansas.
26. Middle of Pitkin in bluff traversed by gully heading at southwest corner of school yard at Iceledo, Arkansas.
29. Red-speckled Pitkin at base of bluff northwest across road from "big spring" north of Cane Hill, Arkansas.
30. Thick shale above first massive limestone in quarry west of road, 0.3 mile south of Leslie, Arkansas.
32. Lower part of Pitkin in creek across bluff southeast of Hurley quarry, northeast of Leslie, Arkansas.
35. Fine-grained, thin bedded limestone at base of Pitkin in low road cut on west side of road on mountain south of Jasper, Arkansas.
37. White, finely oolitic limestone at bluffs above Highway 71, ¾ mile southeast of West Fork, Arkansas.
42. Argillaceous limestone in middle of Pitkin in bluffs above Highway 71, ¾ mile southeast of West Fork, Arkansas.
48. Fine-grained grey limestone above road cut at fault 0.52 mile east of postoffce at Leslie, Arkansas.

1379 blue. Harrison quadrangle, Fodderstack Mountain. Pitkin limestone. Miser, 1914.

1388 blue. Eureka Springs quadrangle, East border of sec. 21, T. 16 N., R. 27 W., Miser, 1914.

1389 blue. Eureka Springs quadrangle, sec. 30, T. 16 N., R. 28 W., Miser, 1914.

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EVIDENCE ON THE NATURE OF CONODONTS

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ABSTRACT—Study of conodont assemblages from strata of McLeansboro, Pennsylvanian, age near La Salle, Illinois, shows that typically a pair of polygnathids, a pair of bryantodids, and several pairs of hindeodellids are present. A rarer type of assemblage is characterized by forms strikingly different in character. From the biological viewpoint it is believed that two taxonomic divisions of the group are represented by these two kinds of assemblages. The zoological relationship of the conodonts with the Paleozoic Annelida is favored. This study and several previous ones show that conodonts which have been previously referred to different "families" may be parts of a single individual. It is advocated that the present nomenclature be removed to the *Ordo Militaris* or "utilitarian" classification proposed by Croneis and that, as far as possible, a biological classification based on phyletic relationships of the assemblages be substituted.

INTRODUCTION

INVESTIGATIONS aimed at solution of the riddle of conodont origin have been conducted along several lines: the description and analysis of new forms, the study and investigation of their chemical composition and histological features, their possible relationships to associated structures and finally, the relationship of one conodont type to another as revealed through a study of conodont assemblages. So long as equivocal associations of conodonts with other groups are unknown, a certain answer to the question of their origin is not yet available. In the meantime, therefore, the study of conodont assemblages perhaps presents the most fruitful line of investigation. Several authors have already undertaken this task, among them, Schmidt (1935), Scott (1935, 1942), and Jones (1938). Schmidt concluded that assemblages collected from the Carboniferous of Germany were related to the branchial apparatus of *Gemundina*-like fish. Both Scott, on the basis of assemblages from the Quadrant shale in the Pennsylvanian of Montana, and Jones, from a study of the assemblages in the Seminole formation (Pennsylvanian) of Oklahoma, concluded that conodonts were in some way related to the Annelida. The series of assemblages described in this paper tends to confirm the conclusions of Scott and Jones.

The writer wishes to express his indebtedness to Carey Croneis for assistance in the preparation of this manuscript, to Michael Chappars for help in the photography, and to Charles W. Sternberg for his assistance in the collection of the shale from which the assemblages were secured.

The strata from which the conodonts were collected are fissile black shales which lie just below the La Salle limestone of McLeansboro (Pennsylvanian) age. Underlying the black shale is a thin seam of coal which varies from one to several inches in thickness. The shale member is about 18 inches thick but tends to vary from one area to another.

The locality from which the shale was collected lies in the SE. ¼ NW. ¼ sec. 6, T. 32 N., R. E., about one and a half miles southeast of Oglesby, and five miles southeast of La Salle, Illinois. Where Bailey Creek, a tributary of the Vermillion River, enters that stream, the creek has cut a rather deep gorge, near the base of which is exposed the conodont bearing shale. Three trips were made to this locality from which a total of about 300 pounds of shale were collected, split, and sorted. As a result, over 75 assemblages and 500 complete individual conodonts were secured for study.

The associated fauna is rather meager as is characteristic of many black shales. The most common fossils, with the exception of the conodonts, are the brachiopods *Orbiculoidea missouriensis* and *Lingula umbonata*. The only other known invertebrates are worm trails or burrows which consist of light gray casts in the black matrix. Vertebrate remains, such as *Lystracanthus* spines, *Cladodus* teeth, and scales referable to some paleoniscid type of fish, although not common, are characteristic of the zone. *Holm-*

sella has been found, not only as individuals, but in sheet-like aggregates suggesting that these "conodonts" are in reality scales of a Paleozoic fish.

DESCRIPTION ANALYSIS OF ASSEMBLAGES

Plate 25, figure 14, depicts the most complete assemblage in the collection. It may be considered as a central type to which all the other assemblages except those shown in figures 7, 15 and 19, may be referred. The original orientation of the separate individuals may be considered as little disturbed. It seems likely, however, that the bryantodids have been moved slightly forward to a position between the plates of the two polygnathids. The individuals present represent members of three known "genera"; an anterior pair of *Streptognathodus*, followed by a pair of *Ozarkodina*, and a posterior group of seven *Hindeodellas*. Lying posteriorly, and to one side of the group, is a single individual of what may be an undescribed "genus," probably related to *Synprioniodina* or *Telumodina*. Several points may be noted: the orientation of the polygnathids is with the blades anterior and the plates behind, opposing one another; the position of the bryantodid pair suggests that the members may have acted against each other; and the hindeodellids are oriented with the denticles inclined to the rear. These observations are based upon the assumption that the polygnathid pair forms the anterior end of the assemblage.

The remainder of the figures belonging to this common type of assemblage suggest that this relationship is a genetic one. With the exception of figures 7, 15, and 19, there is no essential difference in the relationships which the individuals of the separate assemblages bear to one another except insofar as the orientation of the individuals and their "specific" identity are concerned. All of them exhibit signs of an original paired arrangement similar to that shown in figure 14.

Figure 2, however, shows three instead of the customary two polygnathids. There are several possible explanations for this occurrence; there may have been a mixture with another assemblage on the same bedding plane (although no other conodonts were discovered nearby), mixture with another assemblage most of which is on another bedding plane, or, lastly, there may have been no mixture, and the presence of more than two polygnathids may be indicative of some taxonomic difference. If this last be the case, it seems probable that the original number of polygnathids was four and that they were probably symmetrically disposed.

Figure 15 shows a partially uncovered assemblage closely related to the one displayed in figure 19. The former includes individuals referable to *Distacodus*, *Prioniodus*, and *Lonchodina;* the latter comprises forms referable to *Distacodus*, *Lonchodina*, and *Hibbardella* or *Euprioniodina*. These two assemblages differ strikingly from those in the rest of the collection. The individuals belong to different "genera" and are, on the whole, larger and do not possess a similar orientation. A certain orientation is perceptible in the assemblage depicted in figure 19 inasmuch as most of the denticles tend to point in the same direction.

Figure 16 is a photograph of impressions associated with the conodonts. These impressions occur as part of a brown carbonaceous film on the black shale. This film apparently represents a fossilized portion of the cuticle of some worm-like creature. It is believed that the conical structures pictured here represent parapodia or cirri. Not shown

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EXPLANATION OF PLATE 25

(All figures ×14)

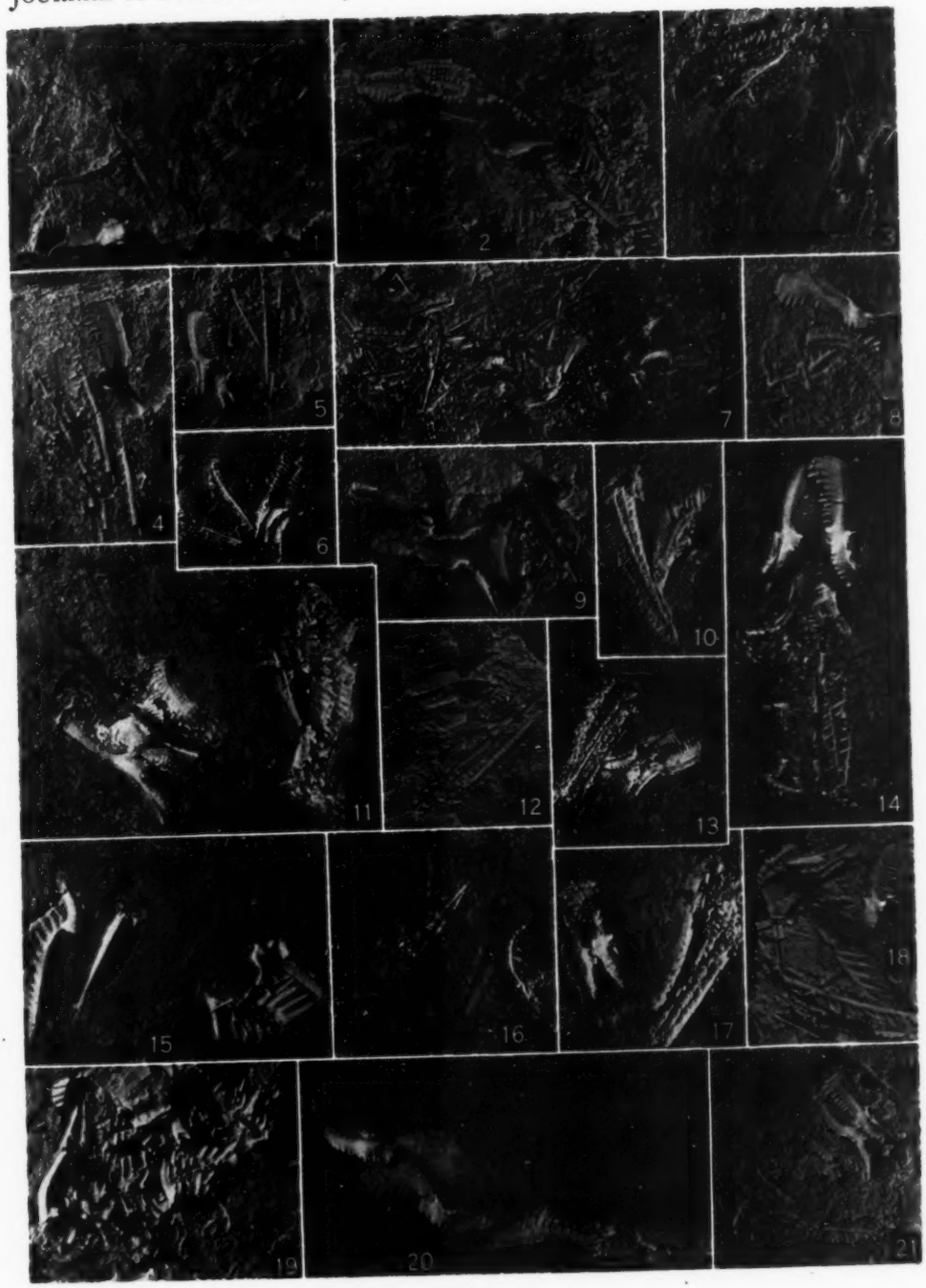
FIGS. *1, 3–6, 8–14, 17, 18, 20, 21*—Series of specimens showing component parts of typical assemblages. Figure *14* depicts the most complete assemblage in the collection.

15, 19—Atypical assemblages composed mainly of *Distacodus*- and *Lonchodina*-like forms.

2—Assemblage in general resembling typical ones but possessing three polygnathids.

7—Coprolitic assemblage composed of polygnathids, hindeodellids, and bryantodids.

16—Problematic parapodia found in association with *Hindeodella*.



DuBois, Conodont Assemblages

UNIV. OF MICH.

in the figure is a hindeodellid which was "sandwiched" between two layers of the membrane and which may indicate in a more positive manner the origin of conodonts. Similar membranous structures have been found in association with some of the assemblages.

Figure 7 depicts an assemblage that is of coprolitic origin. It is included to show the contrast between it and the normal specimens. The ease with which the two types of assemblages may be distinguished is immediately apparent. The individuals present belong to the "genera" *Streptognathodus*, *Ozarkodina*, and *Hindeodella*.

DISCUSSION

Morphology.—Most conodonts seem to represent the pharyngeal and buccal structures of some Paleozoic animal. The standard conodont complement of these structures apparently includes a pair of polygnathids, a pair of bryantodids, and at least four, possibly more, pairs of hindeodellids. The hypothetical proportion of 1:1:4, indicated by a study of the assemblages is borne out by a study of the isolated individuals. Of 479 separate teeth, 67 have been classified as *Ozarkodina*, 108 as *Streptognathodus*, and 304 as *Hindeodella*. Roughly, this is a proportion of about 1:2:5. The large deviation from the hypothetical ratio is apparently due to the differential ability of the teeth to withstand fragmentation. Thus, the number of polygnathids, because of their heavier and more massive construction, probably represents the closest approximation to the number of living individuals now represented as fossil assemblages. Using the polygnathids, then, as unity, it seems that both bryantodids and hindeodellids are present in reduced numbers, and that, relatively the bryantodids have suffered the greater loss in number. Philosophically, however, it would seem reasonable that the reverse may be true. This apparent reversal may be due to either, or both, of two causes: the number of pairs of hindeodellids in an individual may frequently be less than the observed number of four, and thus throw off the assumed generalized ratio of 1:1:4, or, a subjective error may be present in counting the individuals in which fragmentary hindeodellids are counted as whole individuals, whereas fragmentary bryantodids are rejected.

That each group of teeth was surrounded by a separate muscle complex is indicated by the behavior of the groups as units, i.e., paired bryantodids are frequently found with no trace of other teeth nearby; likewise, hindeodellids are frequently found with or without other teeth scattered nearby. Whether there was any significant variation of the fundamental assemblage described above or not is uncertain. Figure 2 indicates the possibility of such a variation, although as has been noted, the assemblage may be fortuitous in part.

In contrast to this more common type of assemblage is another as indicated by the specimens shown in figures 15 and 19. Unfortunately, the poor preservation of the assemblages combined with their rarity gives little clue as to the general arrangement of the component parts.

Phylogenetic relationships.—The evidence offered in these specimens regarding the zoological affinities of conodonts is not wholly positive. A comparison of the assemblages with the lingual teeth of the cyclostomes or with the skeletal elements of the gill arches of fish must show immediately and conclusively that there is no similarity in the arrangement of these structures with the arrangement of the individuals in the conodont assemblage. The radular teeth of gastropods are developed as a series of long rows of more or less morphologically similar individuals that may vary between the separate rows but seldom vary within a given row. A comparison of these teeth with conodonts the assemblages shows that the conodonts could not be derived from snails. For similar reasons it is equally improbable that conodonts represent the lingual teeth of cephalopods. Of the known groups of animals, the teeth seem most closely related to those of the Annelida. This is particularly true when the arrangement of the assemblages is taken into consideration. This possibility is given more weight by the abundance of fossils of probable annelid origin in the beds, e.g., the numerous worm trails, several segmented impressions, and the problematic "parapodia" shown in figure 16.

The question seems capable of final resolution into the fact that conodonts were related to animals belonging to one of three categories; to some as yet unrecognized group of vertebrates, to some unknown group of invertebrates, or to the Paleozoic Annelida. Of the three possibilities, the last seems most probable.

Study of the assemblages further indicates that the animals which bore the structures did not form an entirely homogeneous group. At least two distinct divisions are noted: the most numerous being represented by the specimens similar to the central type shown in figure 14; the other represented by the specimens depicted in figures 15 and 19. These two groups seem to represent a taxonomic distinction of high value. The first group may possibly be subdivided further according to the number of polygnathids present.

Orientation.—The subject of orientation of conodonts has always been a vexing one. This is because of the difficulty of relating them to other objects or to other conodonts, in such a way that the proper perspective is realized. Hass (1941), by a study of the histological structure of the polygnathids concluded that in *Polygnathus* the blade is anterior and the plate posterior. The general aspect of the assemblages seems to indicate this as the proper orientation. In such a way, a "gradient" is realized in which the polygnathids perform the preliminary mastication, and the hindeodellids the final comminution or straining. If this be true, that the polygnathids form the anterior part of the assemblage, then the relations of the bryantodids and hindeodellids are clear; in both cases the majority of denticles are directed in a posterior direction.

Chemical composition.—The most significant argument for not including the conodonts among the Annelida lies in the fact that they are composed in large part of calcium phosphate. F. W. Clarke (1924) states that "some annelids are rich in phosphorus, and the tubes formed by the genera *Leodice*, *Hyalinoecia*, and *Onuphis* are in this respect most remarkable."

The significance of this statement is not immediately obvious. If, however, it is realized that in the chaetopods, the buccal cavity and pharynx are formed by invagination of the embryonic ectoderm, and are thus stomodaeal in origin, then it seems not improbable that annelid jaws are physiologic homologs of the external cuticle, or tube (in the case of tube-building worms). It thus seems much less difficult to postulate a worm having jaws made up largely of calcium phosphate instead of chitin than it did previously. The gap between the secretion of calcium phosphate and that of chitin has not been sufficiently great to prevent the occurrence of both substances in the shells of inarticulate brachiopods. This fact is insufficient proof that the annelids have been capable of secreting calcium phosphate, but it does serve to point out the fact that this substance is not only produced among invertebrates, but may be secreted by the same individual which produces chitin. The possible relationship of the brachiopods to the annelids may be of significance in this respect.

Reconstruction.—If it is assumed that conodonts are associated with both the problematic parapodia and the worm trails, it is possible to erect a picture which may represent the appearance in life of the animal which bore the teeth. The adult was an elongate worm, seldom more than three millimeters in width, with a length of at least three centimeters, and probably five or more. It probably possessed a ventral nerve cord and resembled modern annelids in many other internal structures. Metamerism may have been indicated by the serial development of the jaws, in which each type of tooth was restricted to a separate metamere, and by the presence of regularly arranged parapodia.

The anterior part of the digestive tract was divided into buccal and pharyngeal regions. The buccal cavity had a single (but perhaps more in some cases) polygnathid on either side, with the blade directed anteriorly. These jaws were probably covered with hypodermis and cuticle so that only the actual cusps were visible. Protractor and retractor muscles supported and moved the teeth. Anterior to the polygnathids there may have been one or two teeth of the symmetrical type illustrated in Scott's figure 3c (1935). The pharyngeal region supported

the hindeodellids which probably functioned in the final straining or comminution of the food.

Taxonomic treatment.—Inasmuch as a system of taxonomy should be so constructed as to represent the evolutionary relationships of the animals involved, and because the evidence in the above discussion has shown that structures that have been referred to different families may in reality belong to the same individual, considerable revision of the taxonomic treatment seems necessary. To correct the present terminology by orthodox methods would be extremely difficult and would require years to execute. Indeed it is probable that this problem could never be satisfactorily solved.

The solution which seems most feasible is the complete transfer of the present nomenclature to the *Ordo Militaris* advocated by Carey Croneis (1938) for use in just such cases. This scheme would remove the necessity of a complete revision of the present classification, would allow the further study of conodonts as stratigraphic tools and, at the same time, would permit the separate development of a classification based upon biological relationships. Scott (1942) has already set a precedent for the description of conodont assemblages which should be considered in the erection of any new "natural" genera or species in the group.

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DISTINCTIVE NEW SPECIES OF FORAMINIFERA FROM THE CANE RIVER EOCENE OF LOUISIANA

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ABSTRACT—Eleven species and one genus have been selected from the previously undescribed foraminiferal fauna of the Cane River Eocene of Louisiana as being the most usable species for subsurface correlation. The position of each species in the formation is given. A check-list and list of localities are included.

INTRODUCTION

FOLLOWING the suggestions of men who are thoroughly familiar with the economic paleontology of the Gulf coast, the writer has selected the eleven species of foraminifera described in this paper as being the most useful or most distinctive of the large number of undescribed species which make up the Cane River fauna.

The following descriptions have been taken from a completed manuscript on the Cane River fauna which the author hopes to publish in the near future. In that manuscript previous works on the Cane River formation are reviewed, its lithology is described and its correlation is discussed.

The accompanying check list of species was compiled from samples from two very carefully cored wells in the Urania oil field of Grant and La Salle Parishes, from samples of a completely cored Cane River section in a well in the Georgetown oil field in Grant Parish, and from surface samples collected by Justin Rukas and R. Dana Russell of the Louisiana Geological Survey during their work in Natchitoches and Bienville Parishes, Louisiana. The well core samples give much more accurate information on the range of the useful species than do surface samples but a sufficient number of surface samples were included to be representative of the better surface outcrops.

The well core samples are arranged in descending order and thus, the check-list serves also as a range chart.

Of the species considered herein, only those recorded have been observed in any sample taken from the Weches and Enterprise members.

A comparison of foraminiferal assemblages reveals a close relationship between the faunas of the Weches formation of Texas, the Enterprise greensand of Mississippi and the Cane River formation of Louisiana. The faunal relationships and similarities of lithology indicate that they are at least in part equivalent to each other.

The author wishes to express sincere appreciation to Dr. H. V. Howe, Dr. R. Dana Russell and Justin Rukas of Louisiana State University for the use of samples and type specimens; to Dr. James H. McGuirt, who unselfishly gave much time in consultation and in the preparation of the accompanying plates; and to J. B. Garrett of the Stanolind Oil and Gas Company and M. C. Israelsky of the United Gas Company for the use of slides and for suggestions as to which of the Cane River species are of most value in subsurface correlation.

SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA
Family LITUOLIDAE
Genus CYCLAMMINA H. E. Brady, 1876

CYCLAMMINA CANERIVERENSIS Hussey, n. sp.

Plate 26, figure 12

Test planispiral, entirely involute; chambers numerous about 10 to a whorl, interior labyrinthic, with well developed chitinous inner lining; sutures only slightly depressed; wall thick, of well sorted, fine arenaceous material, well cemented, giving exterior a subvitreous luster; aperture consists of a curved slit at base of last formed chamber and of a curved row of small rounded openings across the apertural face, indistinct except on very well preserved specimens.

Type.—Holotype, no. 2500 from sample Ru 468, Natchitoches Parish, La., diameter 0.74 mm.

This species serves well to mark the upper part of the Cane River formation, as it is of

fairly large size, is easy to distinguish, and occurs in abundance in the uppermost chocolate-brown clays of the formation.

The specimen selected as the type is considered to be a well preserved one, but somewhat small for the species. However, a large number, perhaps even a majority, of the specimens examined have a variety of distorted forms which, if found separately, might be considered as a different species. However, all but the type figured are undoubtedly distorted forms and should be so considered. This species is also found in the chocolate-brown clays that occur in some places at the base of the Cane River. There it is of slightly smaller size and the distorted forms are not so prevalent.

Family VERNEUILINIDAE
Genus PSEUDOCLAVULINA Cushman, 1936
PSEUDOCLAVULINA ELONGATA
Hussey, n. sp.
Plate 26, figures 3, 4

Test very elongate in well developed specimens, triserial in early stages, subtriangular in transverse section, later greater portion of test uniserial, round in transverse section; chambers fairly distinct in early portion, well defined in uniserial portion, inflated, increase in size as added; sutures fairly distinct, slightly depressed; aperture appears to be textularian in early stages, later terminal, rounded without neck or tooth.

Type.—Holotype, no. 2510 from sample 137; length 1.85 mm., width 0.40 mm.

This species occurs in considerable abundance in, and should prove to be a good "marker fossil" for, the greensand section of the Cane River.

Family VALVULINIDAE
Genus GOËSELLA Cushman, 1933
GOËSELLA GIBBOSA Hussey, n. sp.
Plate 26, figure 13

Test in early stages coiled with number of chambers to a whorl, reducing to three then to two, and in the adult a well developed uniserial stage; chambers and sutures indistinct; wall agglutinated, material poorly sorted, includes some tests of small foraminifers, well cemented; aperture appears to be textularian in the early stages but is rounded to elongate, terminal, without tooth in adult.

Type.—Holotype, no. 2508 from sample 118; length 1.50 mm., diameter 0.76 mm.

Probably the most characteristic feature of this species is its lack of distinctive external features. It is necessary to make several sections if the chamber arrangement is to be definitely determined.

The range of this species is rather limited, as it is found only in the upper part of the greensand section.

Genus KARRERIELLA Cushman, 1933
KARRERIELLA OVATA Hussey, n. sp.
Plate 26, figure 5

Test elongate, tapering evenly throughout length, slightly compressed giving ovate shape to transverse section; chambers distinct, somewhat more inflated in adult stages than in earlier portion, slightly overlapping; sutures distinct, depressed; wall arenaceous, composed of well sorted, fine, well cemented grains, aperture on central part of apertural face with a well developed tubular neck.

Type.—Holotype, no. 2512 from sample 169, La Salle Parish, La., length 0.46 mm., diameter 0.26 mm.

This species occurs scattered through the greensand section but is found in greatest abundance in the lower part of that section, in the so-called "salt and pepper" sand.

Family LAGENDIAE
Genus MARGINULINA d'Orbigny, 1826
MARGINULINA VARIATA Hussey, n. sp.
Plate 27, figures 1–8

Test elongate, compressed, subtriangular in transverse section, close coiled early portion may form greater part of the test, later uniserial portion may describe arcuate pattern with chambers increasing in size as added or may be in linear series, last one or two chambers may be smaller and more globose than preceding; periphery varies from broadly rounded through a heavy, thread-like, rounded keel, to a thin, blade-like, translucent keel; sutures all limbate except those between subglobular chambers of those specimens which develop that type of chamber in the adult stage, those sutures are distinctly depressed, limbate feature may extend to face of specimen or may only extend half-way around; wall calcareous, vitreous, very finely perforate; apertural

CHECK LIST

Sample Number	*Cibicides hypoconoides*	*Anomalina nodosa*	*Siphonina carinata*	*Bifarina turriformis*	*Nodoplanulis elongata*	*Nodosaria primitiva*	*Marginulina variata*	*Karreriella ovata*	*Goëselle gibbosa*	*Pseudoclavulina elongata*	*Cyclammina cancriverensis*
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CHECK LIST—*Continued*

Sample Number	*Cibicides hypoconoides*	*Anomalina nodosa*	*Siphonina carinata*	*Bifarina turriformis*	*Nodoplanulis elongata*	*Nodosaria primitiva*	*Marginulina variata*	*Karreriella ovata*	*Goëselle gibbosa*	*Pseudoclavulina elongata*	*Cyclammina cancriverensis*
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CHECK LIST—*Continued*

Sample Number	*Cibicides hypoconoides*	*Anomalina nodosa*	*Siphonina carinata*	*Bifarina turriformis*	*Nodoplanulis elongata*	*Nodosaria primitiva*	*Marginulina variata*	*Karreriella ovata*	*Goësella gibbosa*	*Pseudoclavulina elongata*	*Cyclammina caneriverensis*
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94											
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130				×							
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138											

CHECK LIST—*Continued*

Sample Number	*Cibicides hypoconoides*	*Anomalina nodosa*	*Siphonina carinata*	*Bifarina turriformis*	*Nodoplanulis elongata*	*Nodosaria primitiva*	*Marginulina variata*	*Karreriella ovata*	*Goësella gibbosa*	*Pseudoclavulina elongata*	*Cyclammina caneriverensis*
139	×	××	×				×				
140											
141	××										
142											
143		×									
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CHECK LIST—*Continued*

Sample Number	*Cibicides hypoconoides*	*Anomalina nodosa*	*Siphonina carinata*	*Bifarina turriformis*	*Nodoplanulis elongata*	*Nodosaria primitiva*	*Marginulina variata*	*Karreriella ovata*	*Goësella gibbosa*	*Pseudoclavulina elongata*	*Cyclammina caneriverensis*
184	×	×									
185	×	×						×		×	
186	×	×		×			×			×	
187		×				×					×
188	×						×				×
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190	×	×			×		×	×		×	
191	×	×					×	×			
192	×	×					×				
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196	×	×									
197	×	×		×							
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199		×					×			×	
200		×					×				
201		×		×			×				
202		×								×	

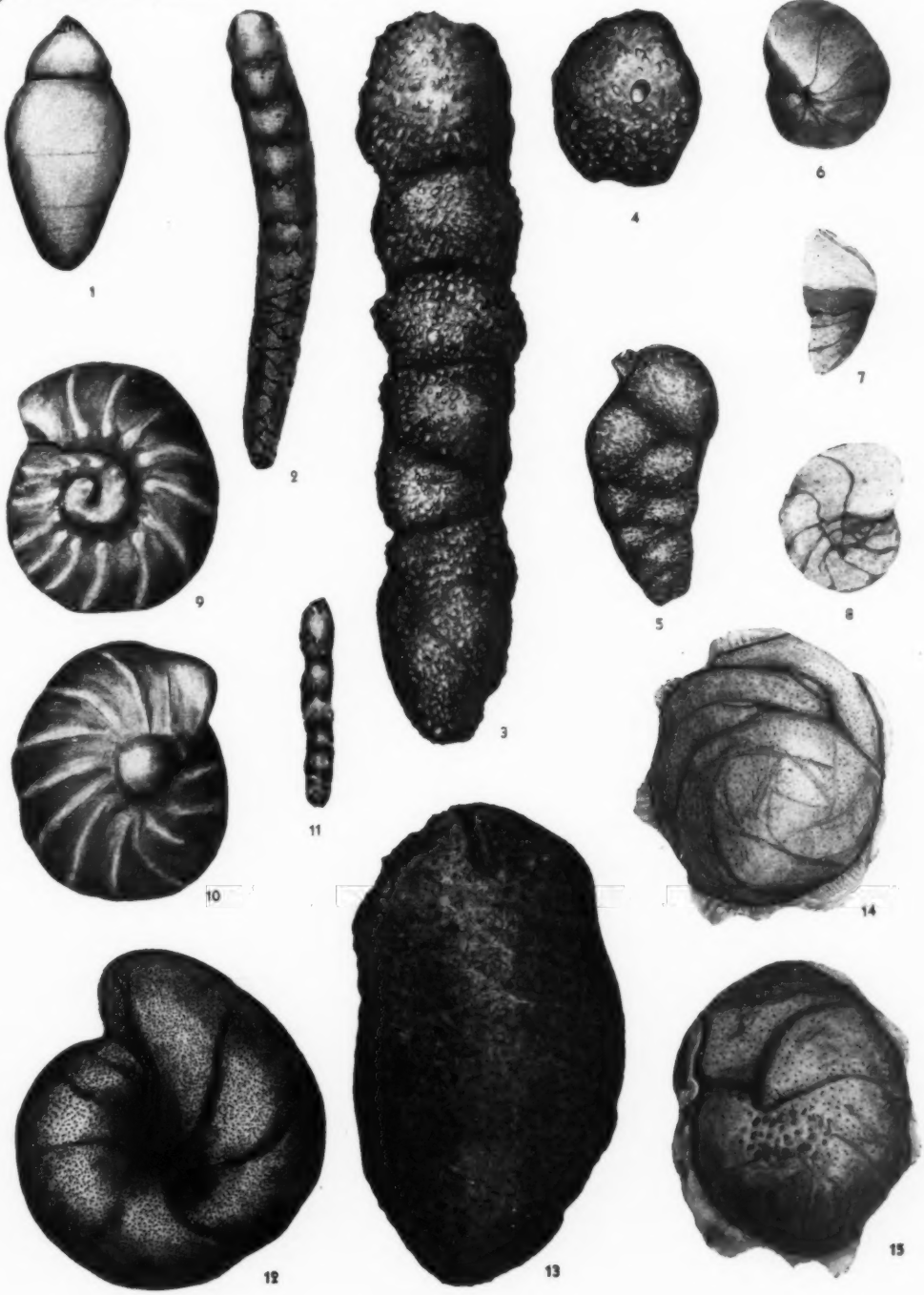
CHECK LIST—*Continued*

Sample Number	*Cibicides hypoconoides*	*Anomalina nodosa*	*Siphonina carinata*	*Bifarina turriformis*	*Nodoplanulis elongata*	*Nodosaria primitiva*	*Marginulina variata*	*Karreriella ovata*	*Goësella gibbosa*	*Pseudoclavulina elongata*	*Cyclammina caneriverensis*
203		×								×	
204		×			×			×		×	
205		×			×			×		×	
206		×									
207		×					×	×			
208	×	×									
209	×										
210	×	×									
211	×	×					×	×			
212	×	×		×			×				
213	×	×					×				
214	×	×		×			×				
215		×									×
216		×									
217		×									
218	×						×			×	
219	×	×					×			×	
Wech.	×		×		×						
Ent.								×			

Wech. Weches samples from Smithville, San Augustine and type localities.
Ent. Enterprise samples from the type locality and from a locality on U. S. highway 51 south of Winona, Mississippi.

EXPLANATION OF PLATE 26

FIGS. *1*—*Nodosaria primitiva* Hussey, n. sp. Holotype, LSU 2549, from sample 115, ×70. (p. 165)
2—*Bifarina turriformis* Hussey, n. sp. Holotype, LSU 2606, from sample 137, ×60. (p. 166)
3, 4—*Pseudoclavulina elongata* Hussey, n. sp. Holotype, LSU 2510, from sample 137, ×50; *3* apertural view of *4*. (p. 161)
5—*Karreriella ovata* Hussey, n. sp. Holotype, LSU 2512, from sample 169, ×75. (p. 161)
6–8—*Cibicides hypoconoides* Hussey, n. sp. Holotype, LSU 2598, from sample 207, ×70; *6*, dorsal view; *7* ventral view, *8* peripheral view. (p. 167)
9, 10—*Anomalina nodosa* Hussey, n. sp. Holotype, LSU 2596, from sample 151, ×75; *10* dorsal view, *9* ventral view. (p. 166)
11—*Nodoplanulis elongata* Hussey, n. gen. Genoholotype, LSU 2563, from sample 136, ×60. (p. 166)
12—*Cyclammina caneriverensis* Hussey, n. sp. Holotype, LSU 2500, from sample 187, ×60. (p. 160)
13—*Goësella gibbosa* Hussey, n. sp. Holotype, LSU 2508, from sample 118, ×50. (p. 161)
14, 15—*Siphonina carinata* Hussey, n. sp. Holotype, LSU 2583, from sample 128, ×75; *14* dorsal view, *15* ventral view. (p. 166)



Hussey, Eocene Foraminifera

Hussey, Eocene Foraminifera

face varies in shape from rounded, vase-shaped to elongate, triangular to broadly rounded; aperture radiate, at peripheral angle.

Types.—Paratypes, no. 2529 from sample Ru 226, Natchitoches Parish, La., length 0.94 mm., width 0.34 mm., thickness 0.30 mm.; no 2530 from sample 119, La Salle Parish, La., length 0.70 mm., width 0.36 mm., thickness 0.26 mm.; no. 2531 from sample 120, La Salle Parish, La., length 0.76 mm., width 0.40 mm., thickness 0.26 mm.; no. 2532 from sample 118, La Salle Parish, La., length 1.02 mm., width 0.50 mm., thickness 0.30 mm.; no. 2533 from sample 123, La Salle Parish, La., length 1.60 mm., width 0.60 mm., thickness 0.38 mm.; no. 2534, from sample 123, La Salle Parish, La., length 1.10 mm., width 0.51 mm., thickness 0.35 mm.; no. 2535 from sample 123, La Salle Parish, La., length 1.08 mm., width 0.60 mm., thickness 0.30 mm.; no. 2536 from sample 148, La Salle Parish, La., length 1.22 mm., width 0.43 mm., thickness 0.24 mm.

This species affords a very interesting study in the great amount of variation that can be developed in a single species in one formation. Figured specimens show a representative group of variations, but there are many other intermediate forms. Specimens are found which display every step from one extreme to the other, even to the variety with beaded sutures which occurs near the top of the Cane River.

This species commonly has been called *Cristellaria nudicostata* in the paleontological reports of various oil companies. According to G. D. Hanna and C. C. Church,[1] *Cristellaria mexicana nudicostata*, *Cristellaria mexicana* var. *nudicostata* and *Marginulina vacavillensis* are all the same form, and of these names *M. vacavillensis* has priority. *C. nudicostata* was raised to the rank of a species by M. C. Israelsky.[2]

Through the kindness of Mr. C. C. Church, some specimens of *M. vacavillensis* were obtained from the type locality, and Mr. M. C. Israelsky kindly loaned specimens from several California localities. The Cane River form was carefully checked against all of those specimens and was found to have finer, more delicate tests. It develops forms that are more bizarre than those in the California samples and seems to be in the gerontic stage of its evolutionary development, whereas, *M. vacavillensis* appears to be a more conservative type. Therefore, it is the opinion of the author that *M. variata* is sufficiently different from the described form to warrant being set up as a new species.

Genus NODOSARIA Lamarck, 1812

NODOSARIA PRIMITIVA Hussey, n. sp.

Plate 26, figure 1

Test elongate, subfusiform, sides nearly parallel; chambers few, not more than six, uniserial, initial chamber large, later ones increase in size only slightly; sutures distinct, broadly depressed; wall calcareous, subporcellaneous, polished; aperture terminal, radiate.

Types.—Holotype, no. 2549 from sample 115, La Salle Parish, La., length 0.49 mm., diameter 0.23 mm.

This species is a very distinctive one. It may, on casual inspection, be mistaken for a member of the genus *Glandulina*, but it should be noted that there is no biserial early stage, neither are the chambers embracing as in *Pseudoglandulina*. It is a very simple species of the genus *Nodosaria*, characterized by the small number of chambers and by the subporcellaneous, polished test.

[1] HANNA, G. D., and Church, C. C., 1937, Notes on *Marginulina vacavillensis* (Hanna), Jour. Paleontology, vol. 11, no. 6, pp. 530–531.

[2] ISRAELSKY, M. C., 1935, Tentative foraminiferal zonation of subsurface Claiborne of Texas and Louisiana, Bull. Am. Assoc. Petr. Geologists, vol. 19, no. 5, pp. 689–695.

EXPLANATION OF PLATE 27

(All figures, ×60)

FIGS. *1–8*—*Marginulina variata* Hussey, n. sp. Cotypes, *1*, LSU 2530, sample 119; *2*, LSU 2529, sample 190; *3*, LSU 2532, sample 118; *4*, LSU 2533, sample 123; *5*, LSU 2531, sample 120; *6*, LSU 2535, sample 123; *7*, LSU 2536, sample 148; *8*, LSU 2534, sample 123. (p. 161)

This species is not limited in range to the chocolate-brown clays of the upper Cane River, but it is found there in greater abundance than in the lower part of the formation.

Family HETEROHELICIDAE
Genus NODOPLANULIS Hussey, n. gen.

Test in early stages showing indications of planispiral ancestry, first three or four chambers have indistinct planispiral arrangement, uniserial arrangement develops directly from initial stage, comprises much the greater part of test; chambers slightly involute; wall calcareous, hyaline, finely perforate; aperture terminal, rounded, with neck.

Genotype, *Nodoplanulis elongata* Hussey, n. sp.

This is one of the more specialized genera of the *Heterohelicidae*, in which the spiral stage is greatly reduced and the biserial stage is wanting.

NODOPLANULIS ELONGATA Hussey, n. sp.
Plate 26, figure 11

Test indistinctly planispiral in very early stage, uniserial stage develops immediately from initial stage and includes much the greater part of test, two or more short, sharp spines on initial end; chambers three or more in planispiral stage, five or more in adult uniserial stage, increase in size as added, slightly compressed; sutures distinct, incised; wall calcareous, hyaline, finely perforate, decorated with a row of blunt, short spines just above the suture line of each chamber; aperture terminal, round, with a very short neck and a flaring lip.

Type.—Holotype, no. 2563 from sample 136, La Salle Parish, La., length 0.52 mm., width 0.08 mm.

Only the very small size of this species prevents it from being one of the most useful "marker fossils" of the Cane River formation. It occurs abundantly enough and appears to be confined to a fairly thin section of the upper part of the formation.

Family BULIMINIDAE
Genus BIFARINA Parker and Jones, 1872
BIFARINA TURRIFORMIS Hussey, n. sp.
Plate 26, figure 2

Test elongate, circular in transverse section, arcuate; chambers in early portion biserial, later ones uniserial, uniserial portion comprises greater part of test; sutures distinct, slightly depressed, distinctly notched; wall calcareous, perforated, pitted, pits arranged in rows, giving striated appearance to test when viewed with direction of light at right angles to longitudinal axis of test; aperture terminal, simple, rounded, encircled by row of blunt spines, not radiate.

Type.—Holotype, no. 2606 from sample 137, La Salle Parish, La., length 1.18 mm., diameter 0.17 mm.

This is both a very distinctive and useful species, as it is of fairly large size, abundant and limited to the greensand marl section of the formation. Its coarsely perforated test, notched sutures and general shape make it easy to identify.

Family ROTALIIDAE
Genus SIPHONINA Reuss, 1850
SIPHONINA CARINATA Hussey, n. sp.
Plate 26, figures 14, 15

Test trochoid, biconvex, compressed, with well developed, broad, thin keel; chambers numerous, early ones indistinct, later ones distinct; early sutures indistinct, hidden on ventral side by reticulate ridges, later ones distinct, depressed on ventral side, limbate, raised on dorsal side; wall calcareous, coarsely perforate; aperture located on ventral side of peripheral line, elongate, puckered internally, neck very short with wide, heavy lip.

Type.—Holotype, no. 2583 from sample 128, La Salle Parish, La., diameter 0.52 mm., thickness 0.22 mm.

A distinctive species with a very unusual aperture, this appears to be an off-shoot from the true *Siphonina*, but it is not different enough to warrant the setting up of a new genus. It is characteristic of the upper part of the greensand marl but specimens also occur lower in the section.

Family ANOMALINIDAE
Genus ANOMALINA d'Orbigny, 1826
ANOMALINA NODOSA Hussey, n. sp.
Plate 26, figures 9, 10

Test trochoid in early stage, later tending to become planispiral and involute; chambers numerous, 12 or more making up last whorl, early chambers on dorsal side hidden by large umbone, ventrally the inner edge

of each chamber terminates in a small node thus forming a ring of nodes along the depressed spiral suture; sutures distinct only in the last formed whorl, limbate; wall calcareous, heavy, perforate; aperture extends across periphery and back along base of last formed chamber on ventral side.

Type.—Holotype, no. 2596 from sample 151, La Salle Parish, La., diameter 0.49 mm., thickness 0.21 mm.

Although this species occurs with and somewhat resembles *Anomalina umbonata*, it is distinct. It can very easily be identified by the node-like terminations of the chambers along the spiral suture and by the fact that it is a smaller species than *A. umbonata*.

This species ranges throughout the Cane River, but has not been found either above or below that formation.

Genus CIBICIDES Montfort, 1808
CIBICIDES HYPOCONOIDES Hussey, n. sp.
Plate 26, figures 6–8

Test small for genus, plano-convex, subconical, trochoid; chambers fairly well defined, eight or more in last formed volution; sutures distinct, slightly depressed in adult stage; wall calcareous, hyaline, finely perforate; aperture extends from periphery back along base of last two chambers.

Type.—Holotype, no. 2598 from sample Ru 518-J, Natchitoches Parish, La., diameter 0.27 mm., thickness 0.14 mm.

This species has a very distinctive shape and appears to be confined to the greensand section of the formation.

LIST OF LOCALITIES

1–106. C. M. Bowers, *et al.* E. T. Morrison No. 1, 3040 feet west of east and 2740 feet north of south line, sec. 24, T. 9 N., R. 1 W., Grant Parish, 106 core samples ranging in depth from 1436 to 1656 feet continuous cores start at 1541 feet.

107–144. Louisiana Oil and Ref. Co., Tremont No. 2, 312 feet east and 345 feet north of southwest cor. SW¼ sec. 29, T. 10 N., R. 2 E., La Salle Parish, 38 core samples ranging in depth from 1468 feet to 1555 feet.

145–183. Louisiana Oil and Ref. Co., Tremont No. 1, 115 feet south and 150 feet east of northwest cor. NW¼ NE¼ sec. 30, T. 10 N., R. 2 E., La Salle Parish, 39 core samples ranging in depth from 1500 feet to 1566 feet.

184–219. (Ru J. M. Rukas) surface localities in Natchitoches Parish, Louisiana.

184. (Ru. 531). NE¼ sec. 3, Ashland township on road to Strange, Louisiana, *Discocyclina advena* zone.

185. (Ru. 510), SE¼, SE¼, NW¼, sec. 8, T. 8 N., R. 8 W.

186. (Ru. 503), type locality of Cane River formation, ½ mile north of Natchitoches, Louisiana.

187. (Ru. 468), from a hand dug well 42 feet deep at Limekiln Church, NW¼ sec. 85, T. 9 N., R. 7 W., greensand marl section.

188. (Ru. 463), 1.4 miles north of Provencal on Provencal-Hagewood road and 0.2 mile east of road, in creek bed, *D. advena* zone.

189. (Ru. 356), 1.2 miles west of cross-roads east of Victoria Hill, SW¼, NW¼, NE¼, sec. 24, T. 8 N., R. 9 W., roadcut, top of *D. advena* zone.

190. (Ru. 226), about 0.6 mile west of Provencal on north side of tracks of Texas & Pacific RR., NW¼, SW¼, SE¼, sec. 20, T. 8 N., R. 8 W., *D. advena* zone.

192–197. (Ru 500B, C, E, F, H, I; Clear Lake bluff exposure, NW¼ sec. 28, T. 11 N., R. 6 W., includes base of chocolate-brown clay and entire greensand marl section of Cane River formation. Is one of best exposures of Cane River in Louisiana.

198–214. (Ru. 518A–Q), NW¼, NE¼, NE¼ Sec. 6, T. ? N., R. 6 W., in center of negro settlement, 40-foot hole extending from 12 feet above *D. advena* zone to 8 feet below it.

215. (Ru. 555), SE¼, SE¼, SE¼ sec. 17, T. 8 N., R. 8 W., bore-hole atop upper Cane River locality, through lower part of chocolate-brown clay into greensand marl.

216. (Ru. 524), 200 yards east of Ru. 523 on north side of road, lower part of chocolate-brown clay section.

217. (Ru. 523), SW¼, NW¼, SW¼ sec. 2, T. 13 N., R. 7 W., in lower part of chocolate-brown clay section.

218. (Ru. 511), NW¼, NW¼ sec. 8, Provencal Township, *D. advena* zone.

219. (Ru. 350), about 2.3 miles south of Hagewood on Louisiana route 39 on side road to west about 400 yards, in SW¼ sec. 8, Provencal Township, *D. advena* zone.

MANUSCRIPT RECEIVED BY THE EDITOR JULY 31, 1941.

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 2, PP. 168–176, PLS. 28, 29, 1 TEXT FIG., MARCH, 1943

CONODONT FAUNA AND DISTRIBUTION OF A LOWER MISSISSIPPIAN BLACK SHALE IN MONTANA AND ALBERTA

CHALMER L. COOPER
Illinois State Geological Survey, Urbana, Illinois
AND
LAURENCE L. SLOSS
Department of Geology, Montana School of Mines, Butte, Montana

ABSTRACT.—Fifty-four species of conodonts are recognized in a black shale member which occurs at the base of the Lower Mississippian Madison group over a wide area extending from Alberta and western North Dakota to southwestern Montana. On the basis of the conodont evidence this horizon is correlated within the Kinderhook of the Mississippi Valley and adjacent areas.

STRATIGRAPHY

THE PRESENCE of a black fissile shale below the Lower Mississippian limestones of the Madison group has been noted previously (Perry, 1928, p. 6; Romine, 1929, p. 790; Moore, 1931, p. 1171; Deiss, 1936, p. 641; Warren, 1937, pp. 454–457; Knechtel and Hass, 1938; Sloss and Hamblin, 1942, pp. 313, 315) and although a partial faunal list was presented by Knechtel and Hass, collections from hitherto unknown occurrences make possible a more thorough description and analysis of the conodont fauna and a discussion of the areal distribution of the shale.

The outcrop collections and stratigraphic data discussed in this paper were gathered by Sloss in the course of field investigations for the Montana Bureau of Mines and Geology during the field seasons of 1938, 1939 and 1940. Description, analysis, and assignment of geologic age of the fauna is by Cooper. It had been hoped in 1939 that the further findings of Messrs. M. M. Knechtel and W. H. Hass of the United States Geological Survey, could be included with this work as a joint paper, but the pressure of their other Survey duties has made this impossible.

Samples in the writers' collections are from the following localities:

1. Steveville Oil field, Alberta (core from a deep well, loaned through the courtesy of Professor P. S. Warren, University of Alberta).
2. Half Moon Canyon, sec. 27, T. 12 N., R. 18 E., Big Snowy Mountains, Fergus County, Montana.
3. Boulder Creek, NW¼ sec. 5, T. 7 N., R. 12 W., Granite County, Montana.
4. Head of Swimming Woman Creek, south flank of Great House Peak, sec. 32, T. 12 N., R. 19 E., Big Snowy Mountains, Fergus County, Montana.
5. Jake Creek Canyon, sec. 13, T. 10 S., R. 33 E., "Blacktail Range," Beaverhead County, Montana.

The black shale occurrence and its fauna in the Little Rocky Mountains have been described by Knechtel and Hass (1938). Other localities at which the shale was observed, but which yielded no fossils, are indicated on the accompanying index map (fig. 1). Other occurrences will probably be found in the course of more detailed work in the northern Rocky Mountain area, as the shale seems to be present wherever the lower shaly (Paine) beds of the Madison conformably overlie the Upper Devonian Three Forks formation.[1] Unfortunately, good exposures of this contact are all too infrequent. The black shale member is absent, however, in areas such as the Pryor and Big Horn Mountains of southern Montana and north-

[1] Since this paper was submitted for publication a core sample was made available for study through the courtesy of Mr. J. M. Kirby of the Standard of British Columbia, from the base of the Madison in his company's MacDougall-Segur well in sec. 11, T. 20 N., R. 12 W., Alberta, from a depth of 3718–3730 feet. A number of conodont species indicate the horizon is the same as the sample from locality 1. This is evidence confirming the writers' opinion that the so-called "Exshaw" of the Alberta plains should be correlated with the basal Lodgepole shale of Montana, rather than with the type Exshaw of western Alberta.

ern Wyoming, where the Madison rests with disconformity on Ordovician strata.

The black shale varies in thickness from about 20 feet in central Montana to over 100 feet in northwestern North Dakota and southwestern Montana. A black shale from 30 to 600 feet thick, in a similar stratigraphic position in the Rocky Mountains of western Alberta, but bearing a Devonian brachiopod and molluscan fauna, has been described by Warren (1937) as the Exshaw shale. No megafossils have been found associated with the conodonts herein described, but the writers propose that this shale member be included as the basal unit of the Lower Mississippian Madison group for the following reasons:

1. Kinderhook age of the conodont fauna.
2. Sharp separation from the underlying Devonian.
3. Gradational transition to the overlying dark shales and intercalated limestones of the Paine member of the Madison.

That the Exshaw shale of Alberta appears to be older than the basal Madison shale in Montana may be explained by one of two hypotheses:

1. The environment requisite to black shale deposition appeared earlier in Alberta than in Montana.
2. The megafauna of the Exshaw is a relic of the Upper Devonian preserved through isolation in the black shale environment which excluded the immigration of new forms.

The presence of Kinderhook conodonts in the core from eastern Alberta lends credence to the latter hypothesis. The writers propose that the basal Mississippian black shale of Montana be treated as the lower member of the Lodgepole formation of the Madison group in Montana.

FAUNAL DISCUSSION

The faunal chart lists a total of 54 species, identified from samples from outcrops in Montana and from the core of a well in the

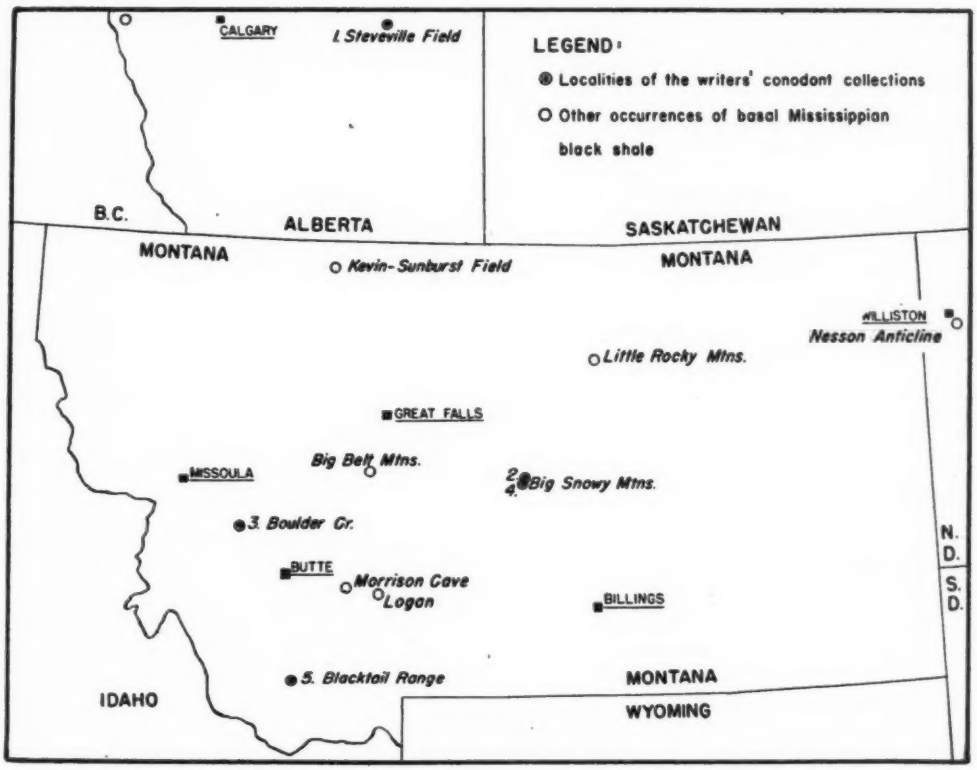


FIG. 1.—Index map showing conodont localities and other basal Mississippian black shale occurrences.

FAUNAL CHART

	This Report: Locality 1	2	3	4	5	Pre-Welden shale[1]	Hannibal shale[2]	Bushberg sandstone[3]	Grassy Creek shale[4]	New Abany Shale[5]: Upper	Middle	Lower	Chattanooga shale[6]	Hardin sandstone[7]	Woodford shale[8]	Arkansas novaculite[9]
Arcugnathus tenuis Cooper	×															
Bryantodus equalis Cooper	×															
Bryantodus mundus Branson and Mehl		×				×									×	
Bryantodus cf. *planus* Branson and Mehl				×		×		×								
Bryantodus serrulus Huddle				×						×						
Dinodus granulosus (Huddle)		×								×						
Euprioniodina prona Huddle		×		×						×						
Falcodus ultimus (Branson and Mehl)				×		×		×		×						
Hibbardella divergens Huddle	×									×						
Hindeodella aculeata Huddle	×					×				×	×					
Hindeodella alternidens Huddle		×								×						
Hindeodella ampla Cooper		×								×						
Hindeodella compressa Huddle	×									×						
Hindeodella conoides Cooper		×														
Hindeodella curvidens Cooper				×											×	×
Hindeodella deflecta Hibbard		×								×	×					
Hindeodella elongata Huddle	×	×		×	×					×						
Hindeodella germana Holmes		×											×			
Hindeodella grandis Huddle	×	×								×						
Hindeodella laticlavis Huddle				×						×						
Hindeodella petila Cooper		×	×												×	×
Hindeodella subtilis Ulrich and Bassler	×	×	×										×	×		×
Ligonodina delicata Branson and Mehl	×					×			×	×						
Ligonodina cf. *flexuosa* Branson and Mehl		×				×			×	×						
Ligonodina gouldi Cooper		×														
Ligonodina tenera Cooper		×				×	×	×								×
Ligonodina sp.				×												
Lonchodina discreta Ulrich and Bassler	×					×				×			×	×	×	×
Lonchodina prava Huddle	×										×					
Ozarkodina dera Cooper	×					×										
Ozarkodina regularis Branson and Mehl	×							×								
Palmatolepis glabra Ulrich and Bassler	×		×						×					×		
Palmatolepis pectenifera ? Huddle				×							×					
Polygnathus scapha Huddle		×				×				×						
Prioniodella cunea Huddle	×									×						
Prioniodina congruens Cooper			×													

FAUNAL CHART—*Continued*

	This Report: Locality 1	2	3	4	5	Pre-Welden shale[1]	Hannfbal shale[2]	Bushberg sandstone[3]	Grassy Creek shale[4]	New Albany Sahle[5]: Upper	Middle	Lower	Chattanooga shale[6]	Hardin sandstone[7]	Woodford shale[8]	Arkansas novaculite[9]
Prioniodus alatoideus Cooper		×				×				×	×				×	
Prioniodus alatoides Holmes	×												×			
Siphonognathus cf. *sexplicata* Branson and Mehl		×				×		×		×						
Solenognathus cf. *anida* Cooper		×				×										
Solenognathus typica Cooper		×				×										
Spathognathodus aciedentatus (E. R. Branson)	×					×	×									
Spathognathodus altus (Branson and Mehl)	×							×								
Spathognathodus angustus Cooper	×															
Spathognathodus crassidentatus (Branson and Mehl)				×		×	×	×		×						
Spathognathodus cyrius (Cooper)	×					×										
Spathognathodus exochus (Cooper)	×					×										
Spathognathodus inornatus (Branson and Mehl)	×								×							
Spathognathodus macrodus (Cooper)	×		×			×										
Spathognathodus mediocris (Branson and Mehl)	×							×								
Spathognathodus praelongus Cooper	×															
Spathognathodus strigilis (Huddle)	×									×		×				
Subbryantodus grandis Cooper	×															
Synprioniodina plana Holmes	×					×				×			×			

[1] Cooper, 1939.
[2] E. R. Branson, 1934.
[3] Branson and Mehl, 1934.
[4] Branson and Mehl, 1934.
[5] Huddle, 1934.
[6] Holmes, 1928.
[7] Ulrich and Bassler, 1926.
[8] Cooper, 1931.
[9] Cooper, 1935.

Steveville Field in Alberta. These are distributed among 21 genera, although three-fifths of the species are classed with four genera, namely, *Bryantodus* (4 species), *Hindeodella* (13), *Ligonodina* (5), and *Spathognathodus* (11). One new genus and eight new species are described. The most remarkable aspect of this northwestern fauna is the exceedingly small number of new species found in it.

The distribution of the 54 species shows that 28 came from the core (loc. 1), 20 from Half Moon Canyon (loc. 2) and 10 from Great House Peak in the Big Snowy Mountains (loc. 4). The fauna is distinctive in that more than 85 per cent of the species can be identified as those also found in the Kinderhook formations of the Mississippi Valley and adjacent areas. Only two species, *Lonchodina prava* Huddle and *Palmatolepis pectenifera?* Huddle, are previously known exclusively from black shales of Devonian age. Because the first occurs rarely in the middle New Albany and the second, of doubtful identification, is abundant at the same horizon, it is assumed that the species range into the basal Mississippian shales. Huddle (1934), in his study of the New Albany shale conodonts, found this to be true of 12 species. As further work adds to our knowledge of conodonts, many more species probably will be found to cross this systemic boundary. It is inconceivable that all of the hundreds of conodont species described from

Devonian and Mississippian horizons are restricted to the single formation in which they are now known to occur.

Compared to previously described faunas, 20 species are known from the pre-Welden shale of Oklahoma (Cooper, 1939) and 23 from the upper New Albany shale of Indiana (Huddle, 1934). Nine species are known from the Bushberg sandstone and scattered occurrences of one to five species are known from the Grassy Creek and Hannibal shales of Missouri, the Hardin sandstone and Chattanooga shale of Tennessee and Alabama, and the Woodford shale and Arkansas novaculite of Oklahoma and Arkansas.

Hass[2] (1938) in a restudy of the material collected by Knechtel from a five-foot dark shale at the base of the Lodgepole limestone of the Madison group in sec. 5, T. 25 N., R. 24 E., in the Little Rocky Mountains, found that all of the conodonts can be identified or compared with previously described species from formations in the Mississippi Valley. He reported 9 species common with the Hannibal, 12 with the Bushberg, 12 with the Bushberg-Hannibal horizon of Oklahoma, 4 with the upper New Albany, 3 with the Chouteau and 1 with the Grassy Creek.

The correlation of these black shales of the northern Rocky Mountain area with similar horizons in the Mississippi Valley seems well established on the conodont evidence.

[2] Personal communication.

SYSTEMATIC DESCRIPTIONS

Genus ARCUGNATHUS Cooper, n. gen.

Bar slender, regularly bowed upward; anterior end denticulated similar to *Hindeodella* with alternating upright teeth; posterior denticles strongly inclined backward; bar terminating in long slender denticle; no main cusp present.

Genotype, *Arcugnathus tenuis* Cooper, n. sp.

ARCUGNATHUS TENUIS Cooper, n. sp.
Plate 29, figure 15

Bar regularly bowed upward, thin, slender; denticles on anterior half slender, elongate, alternating with two or three shorter, more slender ones; denticles on pos-

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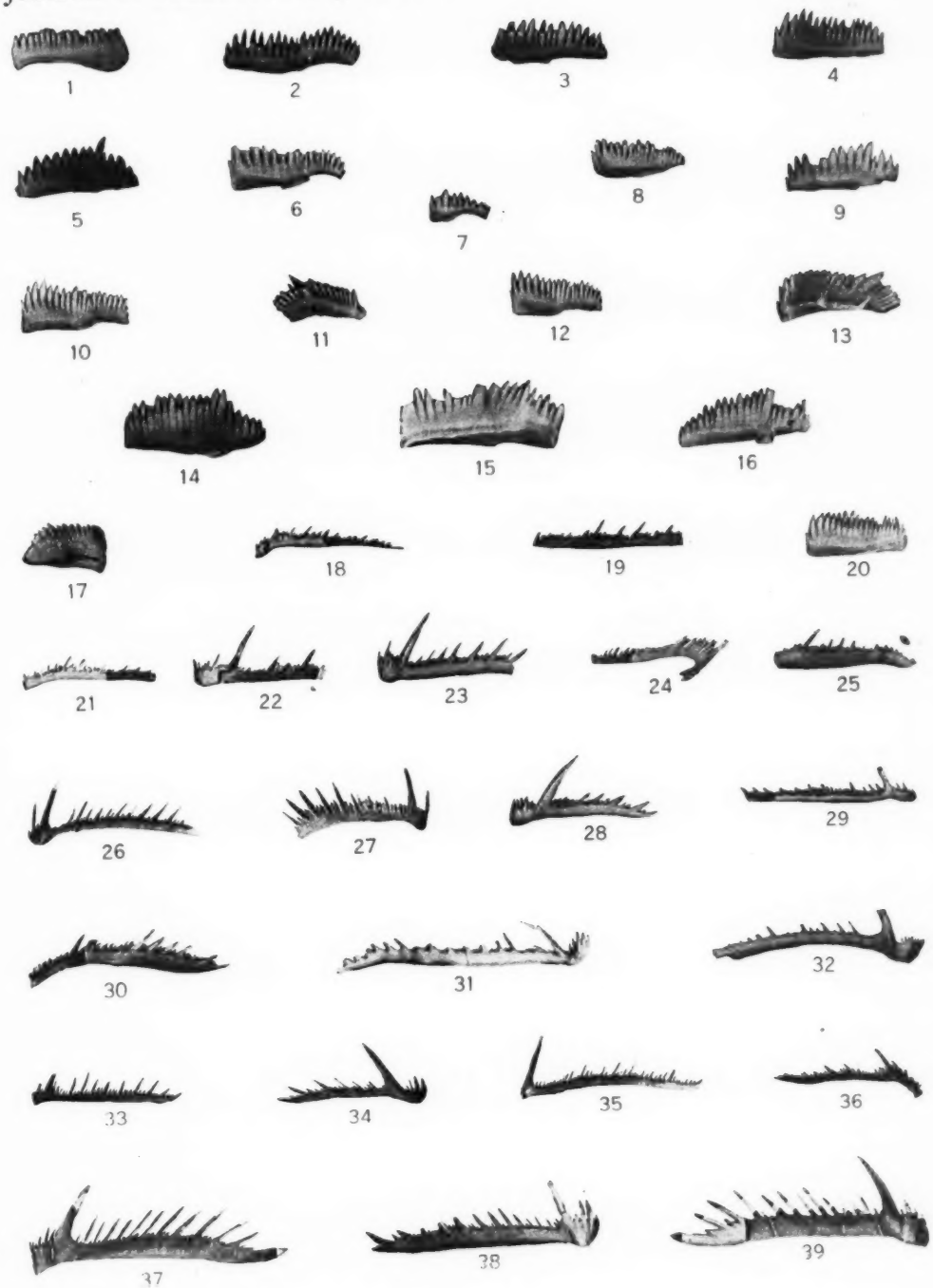
EXPLANATION OF PLATE 28

(All figures magnified 15 times, except as noted)

FIGS. *1*—*Spathognathodus crassidentatus* (Branson and Mehl), loc. 4. (p. 175)
2—*Spathognathodus aciedentatus* (E. R. Branson), loc. 1. (p. 174)
3, 4, 10, 12—*Spathognathodus strigilis* (Huddle), loc. 1. (p. 175)
5—*Spathognathodus mediocris* (Branson and Mehl), ×20, loc. 1. (p. 175)
6—*Spathognathodus cyrius* (Cooper), ×20, loc. 1. (p. 175)
7—*Spathognathodus macrodus* (Cooper), ×20, loc. 1. (p. 175)
8—*Spathognathodus altus* (Branson and Mehl), ×20, loc. 1. (p. 174)
9—*Spathognathodus inornatus* (Branson and Mehl), loc. 1. (p. 175)
11, 17—*Ozarkodina dera* Cooper, loc. 2; *17*, ×20. (p. 170)
13—*Solenognathus typica* Cooper, ×20, loc. 2. (p. 171)
14—*Spathognathodus praelongus* Cooper, n. sp., loc. 1. (p. 175)
15—*Prioniodella cunea* Huddle, ×10, loc. 1. (p. 170)
16—*Spathognathodus exochus* (Cooper), loc. 1. (p. 175)
18, 19, 21, 36—*Hindeodella elongata* Huddle, locs. 1, 2, 4, 5. (p. 170)
20—*Spathognathodus angustus* Cooper, n. sp., loc. 1. (p. 174)
22, 32, 33—*Hindeodella subtilis* Ulrich and Bassler, *22*, ×20, loc. 2; *32, 33*, locs. 1, 3. (p. 170)
23—*Hindeodella alternidens* Huddle, loc. 2. (p. 170)
24—*Euprioniodina prona* Huddle, loc. 4 (see pl. 29, fig. 24). (p. 170)
25—*Hindeodella compressa* Huddle, loc. 1. (p. 170)
26, 35—*Hindeodella petila* Cooper, *26*, loc. 2; *35*, ×10, loc. 3. (p. 170)
27, 34—*Hindeodella deflecta* Hibbard, loc. 2. (p. 170)
28—*Hindeodella germana* Holmes, loc. 2. (p. 170)
29—*Hindeodella aculeata* Huddle, loc. 1. (p. 170)
30—*Hindeodella ampla* Cooper, n. sp., loc. 2. (p. 173)
31, 37, 39—*Hindeodella grandis* Huddle, *31*, ×10, loc. 1; *37, 39*, loc. 2. (p. 170)
38—*Hindeodella laticlavis* Huddle, loc. 4. (p. 170)



Cooper and Sloss, Mississippian Condonts

Cooper and Sloss, Mississippian Conodonts

terior half long, slender, strongly inclined backward.

Locality 1.

Genus DINODUS Cooper

DINODUS GRANULOSUS (Huddle)

Plate 29, figures, 31, 35

Falcodus? granulosus HUDDLE, *1934*, Bull. Am Paleontology, vol. 21, p. 275, pl. 7, fig. 10; upper New Albany shale.

Tooth *V*-shaped, bar forming sides of *V* wide, flat, outer edge very finely denticulate, inner edge somewhat flanged; denticles at bottom of *V* large, strongly curved, those on left bar inclined toward bottom, those on right bar toward top; surface finely granulose.

Locality 2.

Genus FALCODUS Huddle

FALCODUS ULTIMUS (Branson and Mehl)

Plate 29, figure 1

Palmatodella ultima BRANSON AND MEHL, *1934*, Missouri Univ. Studies, vol. 8, p. 292, pl. 23, fig. 21, Bushberg sandstone.

Falcodus conflexus HUDDLE, *1934*, Bull. Am. Paleontology, vol. 21, p. 274, pl. 7, fig. 6, upper New Albany shale. ——. COOPER, *1939*, Jour. Paleontology, vol. 13, p. 387, pl. 47, figs. 26, 34, 42, 43, 45, 46, 52; pre-Welden shale.

Falcodus ultimus. BRANSON AND MEHL, *1938*, Missouri Univ. Studies, vol. 13, pt. 2, p. 131.

Genus HINDEODELLA Ulrich and Bassler

HINDEODELLA AMPLA Cooper, n. sp.

Plate 28, figure 30

Hindeodella sp. HUDDLE, *1934*, Bull. Am. Paleontology, vol. 21, p. 227, pl. 5, fig. 1, upper New Albany shale.

Bar long, wide, thin, flat on central part of aboral side to sharp-edged near posterior end; denticles closely spaced, sharp-edged laterally, broad at base, tapering rapidly to sharp point; one, two or more small denticles alternate with larger ones, last on posterior end larger than others, directed backward almost in line with bar; cusp small, narrow, located well back from anterior end.

Locality 2.

EXPLANATION OF PLATE 29

(All figures magnified 15 times, except as noted)

FIGS. *1*—*Falcodus ultimus* Branson and Mehl, loc. 4. (p. 173)
2—*Lonchodus discreta* Huddle. loc. 1. (p. 174)
3—*Bryantodus* cf. *planus* Branson and Mehl, loc. 4. (p. 170)
4—*Bryantodus serrulus* Huddle, ×20, loc. 4. (p. 170)
5, 36—*Palmatolepis glabra* Ulrich and Bassler, *5*, lateral view, loc. 1; *36*, two moulds showing aboral view, loc. 3. (p. 170)
6, 7, 11—*Prioniodus alatoideus* Cooper, *6, 11*, ×20; loc. 2. (p. 171)
8—*Bryantodus mundus* (Branson and Mehl, loc. 2. (p. 170)
9—*Bryantodus equalis* Cooper, loc. 1. (p. 170)
10, 16—*Hibbardella divergens* Huddle, *16*, ×20; loc. 1. (p. 170)
12—*Ozarkodina regularis* Branson and Mehl, loc. 1. (p. 170)
13—*Lonchodina prava* Huddle, ×10, loc. 1. (p. 170)
14—*Prioniodina congruens* Cooper, n. sp., loc. 3. (p. 174)
15—*Arcugnathus tenuis* Cooper, n. gen., ×20, loc. 1. (p. 172)
17—*Spathognathodus macrodus* (Cooper), ×20, loc. 3. (p. 175)
18—*Hindeodella alternata* Ulrich and Bassler, loc. 4. (p. 170)
19—*Subbryantodus grandis* Cooper, n. sp., loc. 1. (p. 175)
20—*Solenognathus* cf. *anida* Cooper, ×20, loc. 2. (p. 171)
21, 23—*Ligonodina delicata* Branson and Mehl, loc. 1. (p. 170)
22—*Synprioniodina plana* Holmes, loc. 1. (p. 171)
24—*Euprioniodina prona* Huddle, loc. 2 (see pl. 28, fig. 24). (p. 170)
25—*Ligonodina* sp., loc. 4. (p. 170)
26—*Prioniodus alatoides* Holmes, loc. 1. (p. 171)
27—*Ligonodina gouldi* Cooper, loc. 2. (p. 170)
28—*Ligonodina* cf. *flexuosa* Branson and Mehl, loc. 2. (p. 170)
29—*Ligonodina tenera* Cooper, n. sp., loc. 2. (p. 174)
30—*Siphonognathus* cf. *sexplicata* Branson and Mehl, loc. 2. (p. 174)
31, 35—*Dinodus granulosus* (Huddle), loc. 2. (p. 173)
32—*Palmatolepis pectenifera*? Huddle, loc. 4. (p. 170)
33—*Polygnathus scapha* Huddle, loc. 2. (p. 170)
34—*Hindeodella conoides* Cooper, n. sp., loc. 2. (p. 174)

HINDEODELLA CONOIDES Cooper, n. sp.
Plate 29, figure 34

Bar wide, thick, lenticular in section; denticles slightly inclined, conical, crowded, alternating with one or two slightly smaller, similar denticles; cusp about two times size of largest denticles; anterior projection unknown; posterior projection directed aborally, denticulated with strongly inclined teeth.

Locality 2.

Genus LIGONODINA Ulrich and Bassler
LIGONODINA TENERA Cooper, n. sp.
Plate 29, figure 29

Ligonodina delicata E. R. BRANSON, *1934*, Missouri Univ. Studies, vol. 8, p. 328, pl. 27, fig. 3, Hannibal formation. ——. COOPER, *1939*, Jour. Paleontology, vol. 13, p. 390, pl. 45, figs. 50, 60, 61, pre-Welden shale.

Ligonodina sp. BRANSON AND MEHL, *1934*, Missouri Univ. Studies, vol. 8, p. 290, pl. 23, fig. 31, Bushberg sandstone. ——, E. R. BRANSON *1934*, idem., p. 329, pl. 28, figs. 11, 12; Hannibal formation.

Bar thin, flat on aboral side; cusp large, long, moderately curved, circular to lenticular in section; denticles alternating, becoming longer, heavier toward posterior end, sparse or wanting just back of cusp; projection short, thin, with two to four small round denticles.

Locality 2.

This species differs from the holotype of *L. delicata* Branson and Mehl in the very small projection as compared with the size on the Grassy Creek species.

Genus LONCHODINA Ulrich and Bassler
LONCHODINA DISCRETA Ulrich and Bassler
Plate 29, figure 2

Lonchodina discreta ULRICH AND BASSLER, *1926*, Proc. U. S. Nat. Museum, vol. 68, art. 12, p. 36, pl. 10, figs. 1, 2, Hardin sandstone. ——. HOLMES, *1928*, idem., vol. 72, art. 5, p. 26, pl. 9, fig. 13, Chattanooga shale. ——, COOPER, *1935*, Jour. Paleontology, vol. 9, p. 312, pl. 27, fig. 21, Woodford shale and Arkansas novaculite.

Lonchodina distans HUDDLE, *1934*, Bull. Am. Paleontology, vol. 21, p. 270, pl. 6, fig. 13, pl. 10, fig. 3, upper New Albany shale. ——, COOPER, *1939*, Jour. Paleontology, vol. 13, p. 392, pl. 46, fig. 69, pre-Welden shale.

Genus PRIONIODINA Ulrich and Bassler
PRIONIODINA CONGRUENS Cooper, n. sp.
Plate 29, figure 14

Bar elongate, moderately, regularly bowed; denticles straight, slender, elongate, discrete, sides parallel except near sharply terminated tip; cusp about twice as large as denticles, slightly curved and inclined toward posterior.

Locality 3.

Genus SIPHONOGNATHUS Branson and Mehl
SIPHONOGNATHUS SEXPLICATA
Branson and Mehl
Plate 29, figure 30

Siphonognathus sexplicata BRANSON AND MEHL, *1934*, Missouri Univ. Studies, vol. 8, p. 296, pl. 24, figs. 22, 23, Bushberg sandstone.

Polygnathus newalbanyensis HUDDLE, *1934*, Bull. Am. Paleontology, vol. 21, p. 287, pl. 8, fig. 26, upper New Albany shale.

Genus SPATHOGNATHODUS Branson and Mehl
SPATHOGNATHODUS ACIEDENTATUS
(E. R. Branson)
Plate 28, figure 2

Spathodus aciedentatus E. R. BRANSON, *1934*, Missouri Univ. Studies, vol. 8, p. 306, pl. 21, figs. 21, 23, Hannibal formation. ——. COOPER, *1939*, Jour. Paleontology, vol. 13, p. 413, pl. 45, figs. 26, 28, 44, pre-Welden shale.

SPATHOGNATHODUS ALTUS
(Branson and Mehl)
Plate 28, figure 8

Spathodus altus BRANSON AND MEHL, *1934*, Missouri Univ. Studies, vol. 8, p. 275, pl. 22, fig. 15, Bushberg sandstone.

SPATHOGNATHODUS ANGUSTUS Cooper, n. sp.
Plate 28, figure 20

Bar almost straight, thin; escutcheon small, subcentral, causing slight flaring of bar; denticles closely spaced, fused for approximately half their length, upper half tapering to sharp point; denticles near anterior end wider, longer than those on posterior end.

Locality 1.

SPATHOGNATHODUS CRASSIDENTATUS
(Branson and Mehl)
Plate 28, figure 1

Spathodus crassidentatus BRANSON AND MEHL, *1934*, Missouri Univ. Studies, vol. 8, p. 276, pl. 22, figs. 17, 18, Bushberg sandstone. ——. E. R. BRANSON, *1934*, idem., p. 303, pl. 27, fig. 12, Hannibal formation. ——. COOPER, *1939*, Jour. Paleontology, vol. 13, p. 413, pl. 45, fig. 19, pre-Welden shale.

Spathodus parvus HUDDLE, *1934*, Bull. Am. Paleontology, vol. 21, p. 276, pl. 7, fig. 16, upper New Albany shale.

SPATHOGNATHODUS CYRIUS (Cooper)
Plate 28, figure 6

Spathodus cyrius COOPER, *1939*, Jour. Paleontology, vol. 13, p. 413, pl. 45, fig. 25, pre-Welden shale.

SPATHOGNATHODUS EXOCHUS (Cooper)
Plate 28, figure 16

Spathodus exochus COOPER, *1939*, Jour. Paleontology, vol. 13, p. 413, pl. 45, fig. 30, pre-Welden shale.

SPATHOGNATHODUS INORNATUS
(Branson and Mehl)
Plate 28, figure 9

Spathodus inornatus BRANSON AND MEHL, *1934*, Missouri Univ. Studies, vol. 8, p. 185, pl. 17, fig. 23, Grassy Creek shale.

SPATHOGNATHODUS MACRODUS (Cooper)
Plate 28, figure 7; plate 29, figure 17

Spathodus macrodus COOPER, *1939*, Jour. Paleontology, vol. 13, p. 415, pl. 45, fig. 23, pre-Welden shale.

SPATHOGNATHODUS MEDIOCRIS
(Branson and Mehl)
Plate 28, figure 5

Spathodus mediocris BRANSON AND MEHL, *1934*, Missouri Univ. Studies, vol. 8, p. 277, pl. 22, fig. 21, Bushberg sandstone.

SPATHOGNATHODUS PRAELONGUS
Cooper, n. sp.
Plate 28, figure 14

Bar thin, straight, with small escutcheon subcentral; denticles very long, crowded to fused for two-thirds to three-fourths of their length, upper portion tapering gradually to sharp point.

Locality 1.

Similar to *S. rectus* (Branson and Mehl) but denticles are more crowded and escutcheon is smaller and more nearly central.

SPATHOGNATHODUS STRIGILIS (Huddle)
Plate 28, figures 3, 4, 10, 12

Spathodus strigilis HUDDLE, *1934*, Bull. Am. Paleontology, vol. 21, p. 275, pl. 7, fig. 15, pl. 12, fig. 11, upper and lower New Albany shale. ——. COOPER, *1939*, Jour. Paleontology, vol. 13, p. 416, pl. 45, fig. 37, pre-Welden shale.

Genus SUBBRYANTODUS Branson and Mehl

SUBBRYANTODUS GRANDIS Cooper, n. sp.
Plate 29, figure 19

Bar elongate, narrow, slightly bowed near center; denticles discrete for most of length, tapering, round in cross-section, upright on anterior end, moderately inclined back of cusp; cusp similar to but longer and thicker than denticles.

Locality 1.

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PARANONION, A NEW GENUS OF FORAMINIFERA FROM THE MIOCENE OF VENEZUELA

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ABSTRACT—A new genus, *Paranonion*, derived from *Nonion*, and its genotype, *P. venezuelanum*, n. sp., are described from the upper Miocene of Venezuela.

IN THE upper Miocene sections of wells in in the northern part of the State of Monagas, Venezuela, there occurs an abundance of a new foraminifer, whose similarity to *Nonion* and whose ontogenetic development quite definitely place it in the family *Nonionidae*. The genus, because of its direct derivation from *Nonion*, is here named *Paranonion*.

Like *Nonion*, *Paranonion* is hyaline, planispiral, finely perforate and involute in the young stages. It differs from *Nonion* in apertural position, type of aperture, and tendency to become evolute in the late stages. The apertural position is the same as in *Burseolina*, *Cristellariopsis*, *Cushmanella* and *Eponidella*, but the first three of these genera have a different type of aperture, while the last two possess supplementary umbilical chambers, a feature which *Paranonion* lacks.

The aperture of *Paranonion* is an oval opening slightly below the middle of the septal face. Only in the most mature specimens is a lip formed, and in all cases its development is slight. In young specimens the aperture is a high arch open to the base of the septal face. As the foraminifer matures, a thin plate appears, separating the opening from the base of the septal face. This plate is strengthened from left to right until, in the ephebic stage, no vestige remains of the original extent of the aperture. The development of the aperture is illustrated by the paratypes (pl. 30, figs. 4*b*, 3*b*, and 2*b*). In figure 2*b* the aperture has attained its final shape, but the plate separating it from the base of the septal face is still very thin. The paratypes illustrated by figures 4*b* and 3*b* show a less mature stage in the ontogeny, the thin plate thickening from left to right. The genotype (pl. 30, fig. 1*b*) illustrates the mature specimen in which the partial block of the aperture and the development of a slight lip are completed.

From the prolific associated fauna, it appears that *Paranonion* frequented a warm, shallow, marine habitat. In addition, it was found in characteristically shallow marine sediments of massive to bedded, soft, frequently laminated shales. Because this genus is known only from its type species, there is a possibility that its range in depth may be extended as additional new species are encountered.

Acknowledgements.—This paper is published with the permission of the Standard Oil Company of Venezuela. The authors are also indebted to Dr. J. J. Galloway, of the University of Indiana, whose preparation of the figures and aid in taxonomy helped make this publication possible. A. N. Dusenbury, Jr. assisted in the preparation of the manuscript.

SYSTEMATIC DESCRIPTIONS

Family NONIONIDAE Reuss, 1860
Sub-family NONIONINAE Schultze, 1854
Genus PARANONION Logue and Haas, n. gen.

Test minute, planispiral, involute in young stages, tending to become evolute in last few chambers; wall calcareous, hyaline, very finely perforate; aperture in adult an oval opening near middle of septal face, in young a high arch more or less open to base of septal face. Geologic range, upper Miocene. Warm, shallow, marine water.

Genotype, *Paranonion venezuelanum* Logue and Haas, n. sp.

This genus was obviously derived from *Nonion* by tending to become evolute, and by the concomitant blocking of the lower part of the aperture.

PARANONION VENEZUELANUM Logue and Haas, n. sp.
Plate 30, figures 1–4

Test minute, nearly perfectly planispiral, biconvex, biumbonate, thickest in axis, completely involute in young stages, tending to become evolute in last three or four chambers; whorls about two, with eight to ten chambers to a whorl; chambers closely appressed in earlier stages, becoming slightly less appressed in last few chambers; periphery rounded, slightly lobulate, especially in last few chambers; sutures gently curved, highly limbate by addition of secondary, imperforate calcareous material; more thickened toward umbones, often very slightly raised; surface smooth, perforate wall appearing dark, imperforate exogenous material appearing white; wall calcareous, hyaline, very finely perforate; aperture in adult a transverse, oval to reniform opening somewhat below middle of septal face, with slightly raised lip; aperture in immature specimens a transverse oval or high arch, either connected with base of septal face or separated from it by a thin plate, with slightly raised rim.

Length, or greatest diameter of holotype, 0.31 mm.; thickness, 0.14 mm. Paratypes are slightly smaller.

Occurrence.—Common in the upper Miocene portion of the La Pica formation in wells drilled in the northern part of the State on Monagas, Venezuela. As the La Pica is normally covered by continental Pliocene and Pleistocene deposits in this region, occurrences in outcrops have never been found. In the sample in which it was originally discovered *Paranonion venezuelanum* is associated with *Rotalia beccarii* var. *sobrina*, *Haplophragmoides* sp., *Eggerella?* sp., sponge spicules, *Spirorbis?* sp., unidentifiable small pyritized pelecypod casts, *Laevidentalium* sp., fragments of an ophiuroid vertebral ossicle, *Cytherella* sp., otoliths, and a fish tooth.

Types.—Holotype, U. S. Nat. Mus.

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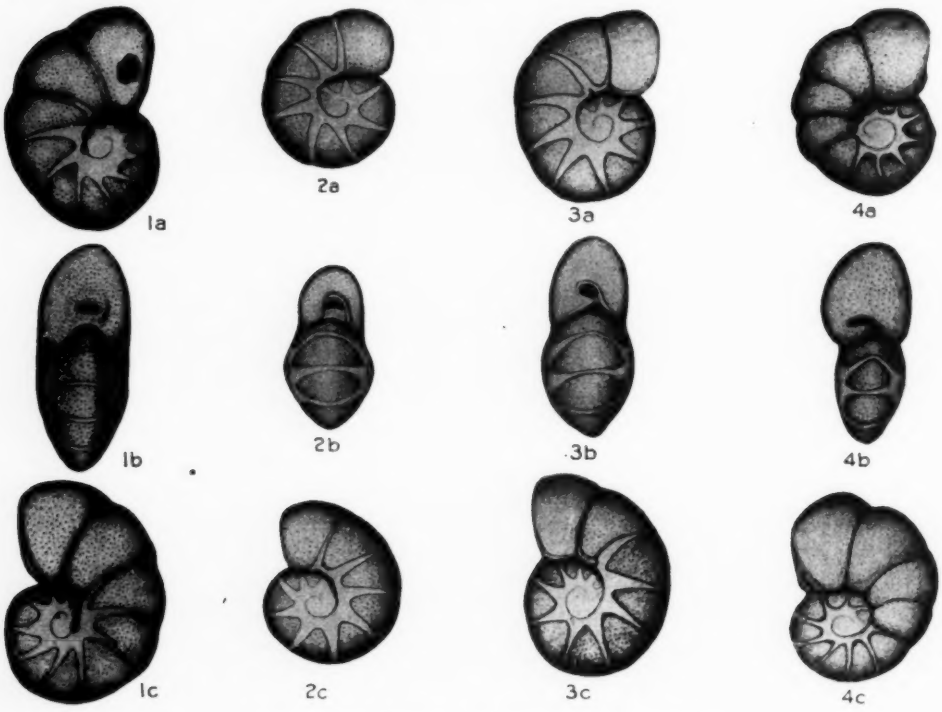
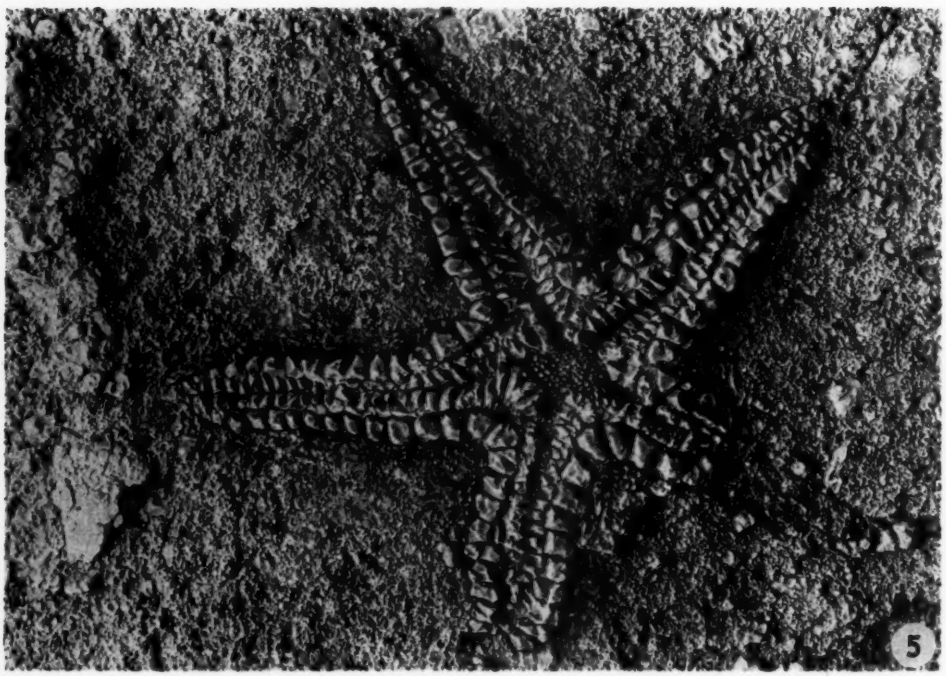


Logue and Haas, Miocene Foraminifer



Miller and Unklesbay, Jurassic Asteroid

UNIV. OF MICH.

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 2, PP. 179–180, PL. 30, MARCH, 1943

A NEW ASTEROID FROM THE JURASSIC OF CENTRAL WYOMING

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ABSTRACT—A unique asteroid from the Sundance formation of the Owl Creek Mountains is illustrated and described in this paper, and the specific name *Astropecten péwéi* is proposed for it.

ASTEROIDS, though perhaps more persistent than any other group of echinoderms, are rather rare as fossils. Although a considerable variety of forms is known from the Jurassic of Great Britain and continental Europe, only two finds have been reported previously from contemporaneous strata in the United States.

Long ago, Whitfield (1880) described as *Asterias? dubium* three poorly preserved specimens crowded together on a small block of red Jurassic sandstone from the Black Hills of South Dakota. Whitfield's illustration and description were subsequently republished by Clark (1893) and by Clark and Twitchell (1915), but little additional information is given by these later authors. In 1900 Logan illustrated and briefly described another poorly preserved specimen from "bluish" Jurassic shale in the Freeze-out Hills of southeastern Wyoming. He referred this specimen to Whitfield's species, but neither his illustration nor his description indicates that his identification is correct. As a matter of fact, both Whitfield's and Logan's specimens seem to be so poorly preserved that even their generic affinities cannot be determined with certainty, nor can satisfactory comparisons be made with the specimen on which the present report is based. This latter specimen was found by Mr. Troy L. Péwé during the summer of 1941 in the Sundance formation of the Owl Creek Mountains of central Wyoming. Although its preservation leaves much to be desired and only its ventral side is exposed, it seems to be referable to the genus *Astropecten*, and to represent a new species which we are naming in honor of its discoverer.

ASTROPECTEN PÉWÉI Miller and Unklesbay, n. sp.
Plate 30, figure 5

The holotype is rather small, and its overall diameter is estimated to have been about 35 mm. The length of the arms measures about 15 mm., and the diameter of the disk about 7 mm. At their junction with the disk, the arms are about 5.5 mm. wide. Their margins are essentially straight, and the arms taper gradually and regularly throughout their entire length.

Although some of the arms are slightly curved, the best-preserved arm is essentially straight. This arm consists primarily of four distinct rows of plates or ossicles. The outer two of these rows probably are superomarginal plates, as the inferomarginals seem to have been eroded away. The inner two rows in this arm apparently are ambulacral ossicles, and near the proximal end of the arm are the remains of what we believe to be adambulacral plates. There are approximately 20 marginal plates on each side of this arm. Both supero- and inferomarginals are visible on each side of the proximal portion of the slightly crushed arm in the lower right part of plate 30, figure 5.

Modern representatives of this genus bear numerous spines in association with the

EXPLANATION OF PLATE 30

FIGS. *1–4—Paranonion venezuelanum* Logue and Haas, n. sp. *1*, holotype, mature specimen; *2–4*, paratypes, immature specimens showing apertural development; *a* and *c*, lateral views; *b*, apertural view. All figures by Dr. J. J. Galloway; ×100. (p. 178)
5—The holotype of *Astropecten péwéi* Miller and Unklesbay, n. sp., from the Sundance formation in the extreme western part of the Owl Creek Mountains of Wyoming, ×4. (p. 179)

marginal plates, but in the specimen under consideration, no trace of such spines is discernible. The numerous small circular structures visible in the large depression near the center of the disk of this specimen almost certainly represent the bases of small dorsal spines.

Remarks.—The genus *Astropecten*, as now interpreted, includes a variety of living species and a considerable number of fossil forms. The latter range back to the Lower and Middle Jurassic of England, the Middle Jurassic of continental Europe, and the Cretaceous of South America. The majority of the Mesozoic species that have been established are based on dissociated plates, but a few of the English Jurassic forms are remarkably well preserved, as are some of those known from the Tertiary.

The specimen on which the present study is based is the first representative of the genus *Astropecten* to be described from the Mesozoic of the United States. It does not seem to be particularly similar to any of the congeneric forms known from Europe, but inasmuch as only the ventral side of it is visible, satisfactory comparisons are not possible in all cases. In the syntypes of *Asterias? dubium* Whitfield, which also came from the Sundance formation, the arms are relatively long and slender.

Occurrence.—The above-described specimen came from a buff arenaceous fossiliferous limestone approximately 75 feet above the base of the Sundance formation about 3 miles south of Red Peak and 1 mile east of Red Creek, in the extreme western part of the Owl Creek Mountains of Wyoming. The Sundance is about 360 feet thick at this locality.

Repository.—State University of Iowa, 2149.

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JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 2, PP. 181–195, PL. 31, 6 TEXT FIGS., MARCH, 1943

THE PENDLETON FORMATION, LOUISIANA AND TEXAS

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ABSTRACT—The name Pendleton formation is proposed for the lower Eocene sediments outcropping around the southern margin of the Sabine uplift in Louisiana and Texas which have been referred to previously as the Pendleton faunal unit. Mappable marine beds occur at both the top and bottom of this unit and furnish definite limits for the formation. Three characteristic lithologic sequences occur within the formation and these are set up as members. Also three faunal zones, closely agreeing with the lithologic members are defined. Further evidence supporting the correlation of this formation with the Tuscahoma formation of Alabama is presented. A strike section, into which are projected the major stratigraphic sequences along the formation outcrop, showing the lateral variation in sedimentation, and a range chart showing the distribution of the more important fossil species are included.

INTRODUCTION

EARLY geological work indicated that a large structural dome, the Sabine uplift, exists in northwestern Louisiana and eastern Texas. On this uplift is exposed a thick section of lower Eocene sediments which outcrops over its crest and around its southern margin. Although most of these sediments are barren a few fossiliferous exposures were found at an early date on the southern flank of the uplift and correlations were made with the marine Wilcox of Alabama. As a result of these correlations all of the lower Eocene sediments in this region were mapped as undifferentiated Sabine (Wilcox).[1]

The published results of field work by the Louisiana Geological Survey in 1939 and 1940 have shown that several lithologic sequences or cycles of sedimentation can be mapped and that mappable fossiliferous marine beds occur within each cycle or subdivision of this lower Eocene section. LeBlanc (1941) noted the presence of Midway fossils in the lower portion of the formerly "undifferentiated Wilcox" and Barry (1941) subdivided the Sabine (Wilcox) into three faunal units named (oldest to youngest) Marthaville, Pendleton, and Sabinetown after localities where fossiliferous exposures had long permitted correlation with the Alabama section.

The recognition of these subdivisions has permitted more detailed geological mapping and the writers' field work within the outcrop area of the Pendleton faunal unit in Sabine Parish, Louisiana and Sabine Coun-

FIG. 1—Index map showing areas covered in figures 3 and 5.

[1] The writers have no desire to enter into a discussion of the relative merits of the terms Sabine and Wilcox. For a thorough discussion of the two terms see Howe (1933). Although the name Sabine is used by the Louisiana Geological Survery, the name Wilcox is in general usage outside the State, and this group of lower Eocene sediments, therefore, will be referred to as the Sabine (Wilcox) in this paper.

ty, Texas (see fig. 1) shows that this faunal unit consists of mappable lithologic sequences which are characterized by fossiliferous marine beds. It is the purpose of this paper to more accurately define the beds containing the Pendleton fauna, to analyze this fauna, to define and describe the biostratigraphic zones within these beds, and to assign them formational rank.

The writers are grateful to J. L. Woods for permission to publish information gained while in the employ of the Brownwoods Oil Corporation.

Identification of fossils and establishment of faunal zones was aided by the use of identified collections made by J. O. Barry and R. J. LeBlanc, former graduate students of Louisiana State University, who have done recent work in this area. Mr. LeBlanc was of special assistance in solving certain stratigraphic problems and in identifying a number of fossil species.

The writers wish to express their appreciation to Dr. H. N. Fisk, Associate Professor of Geology, who directed their work, and to Dr. H. V. Howe, Director of the School of Geology, Louisiana State University, who checked the identification of the Ostracoda listed.

THE PENDLETON FORMATION

The Pendleton formation, from 275 to 300 feet thick, includes the strata occurring between the base of the first marine sand above the Marthaville faunal unit as established by Barry (1941) and the base of the first marine sand (Pierson glauconite[2]) of the Sabinetown faunal unit.[3]

The classic fossiliferous exposure at old Pendleton Ferry, Sabine County, Texas, is selected as the type locality of the Pendleton formation (see fig. 2). This outcrop is particularly well suited to serve as the type

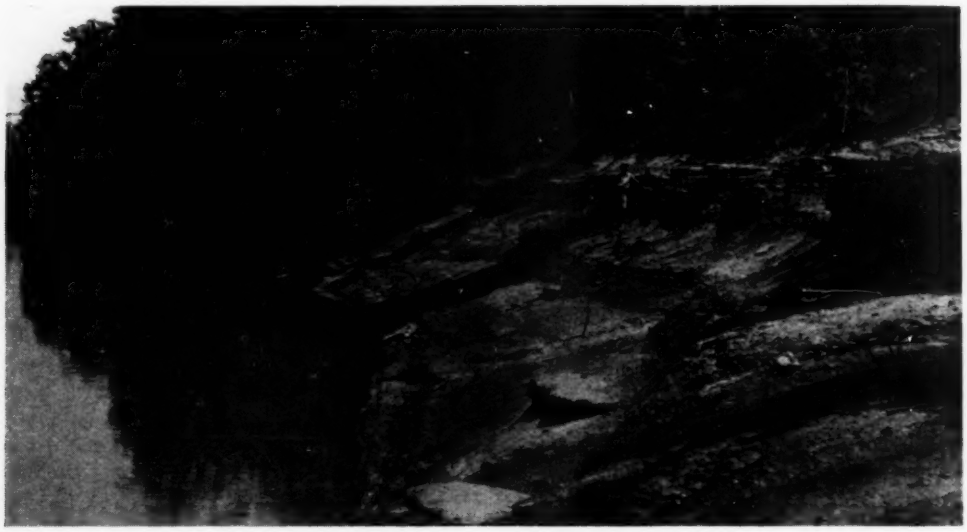

FIG. 2—Outcrop of the Pendleton formation at its type locality at the old Pendleton Ferry. Photo by Alec Osanik.

[2] The term Pierson glauconite was first used in the field notes of Mr. Justin Rukas, Louisiana Geological Survey, as a name for the glauconitic sands cropping out near the railway station of Pierson, just north of the town of Natchitoches, Louisiana. The name is applied in this paper to the westward extension of this bed through western Louisiana and into Sabine County, Texas (see S_p on fig. 5).

[3] Barry (1941) set up three faunal units in the Sabine (Wilcox) of Louisiana. Barry and LeBlanc (1942) recognize the Marthaville beds as a formation, almost coincident with the previously established Marthaville faunal unit, whereas the Pendleton and Sabinetown beds retain the rank of faunal units. The authors of this paper accept the usage of Marthaville as a formation, and give formation rank to the Pendleton beds. The Sabinetown alone remains a faunal unit (see fig. 6).

locality because it is well known, because it contains a distinctive fauna which can be correlated regionally, and because it occupies a stratigraphic position near the center of the section of the Pendleton formation. The following beds are exposed at the old ferry landing, one-fourth mile upstream from the present Sabine River Bridge connecting

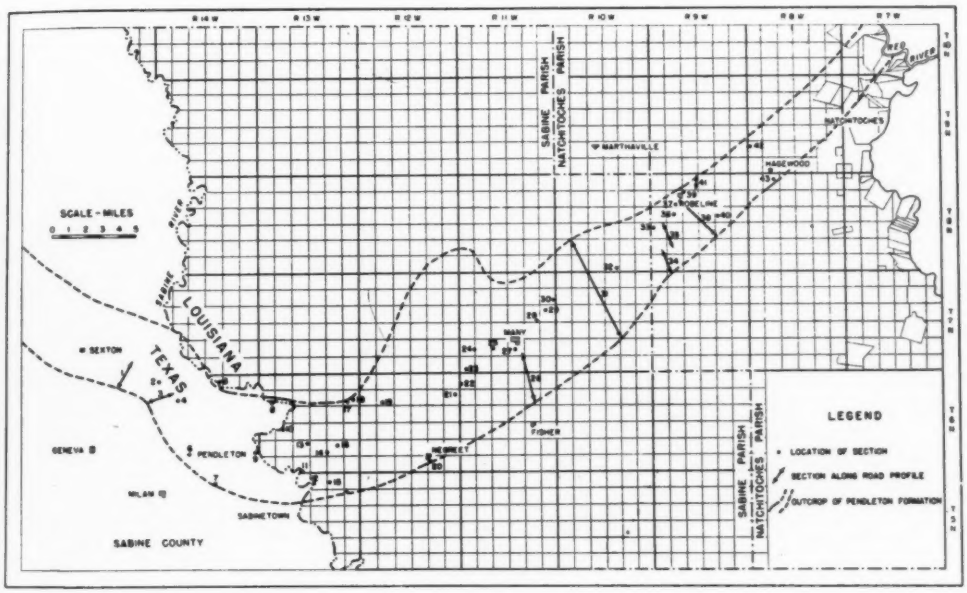

FIG. 3—Distribution of the Pendleton formation in eastern Texas and western Louisiana.

Texas Highway 21 and Louisiana Highway 6. The stratigraphic position of this section is shown on figure 4, column 9.

Type section of Pendleton formation

	Feet
Clays, dark, thin-bedded and silts, sandy.	15
Concretionary ledge	2
Sand, fossiliferous, glauconitic with pipe-like limonitic nodules, concretions at base	5
Clay, wavy, lignitic alternating with silt, sandy	9

The outcrop at Pendleton Ferry has aroused the interest of geologists since Harris and Veatch (1899) first observed fossiliferous beds there. They collected and analyzed this fauna, and correlated it with that of the Tuscahoma formation of Alabama. Since that time many authors have noted this outcrop and referred to it in their writings. Plummer (1933) included the Pendleton Ferry beds along with the fossiliferous outcrops at Sabinetown, Texas, in his Sabinetown formation, which he correlated with the Bashi formation of Alabama. Howe and Garrett (1934) on the basis of Ostracoda, and Barry (1941) on the basis of extensive molluscan collections reaffirmed Harris' original correlation of the Pendleton Ferry beds with the Tuscahoma formation. The work of the authors of this paper also supports this correlation.

The Pendleton formation outcrops along the southern edge of the Sabine uplift in a well-dissected highland region of considerable topographic relief. Elevations vary from 120 feet on Sabine River to over 400 feet in Sabine County, Texas, and throughout the entire region tributary streams have eroded valleys and exposed excellent sections of these lower Eocene sediments.

The Pendleton beds can be traced eastward and westward from Sabine River, and their outcrop exhibits a pronounced change in strike (see fig. 3) which reflects the struc-

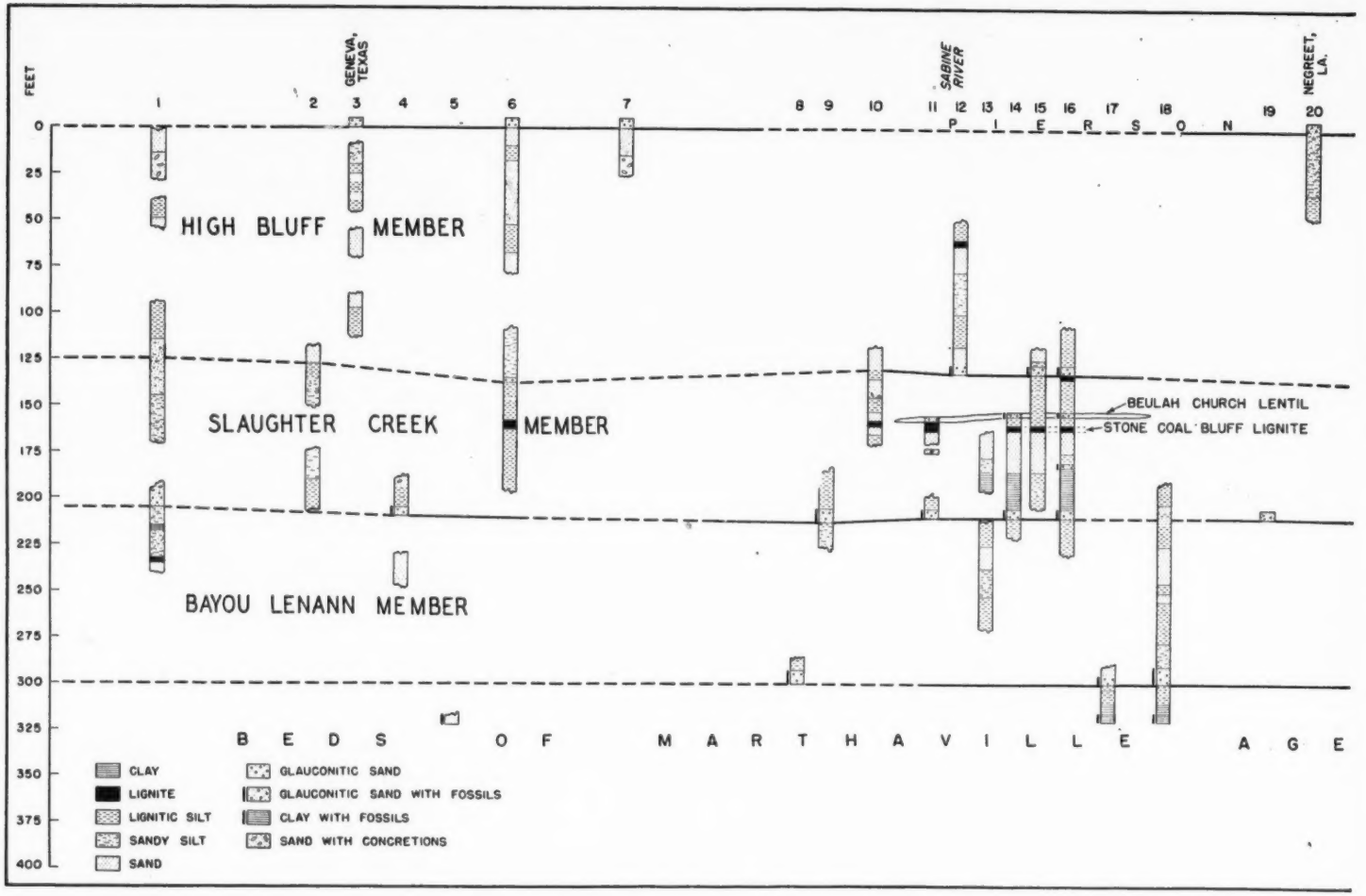

FIG. 4—Stratigraphic relations of the subdivisions of the Pendleton formation on the outcrop in eastern Texas and western Louisiana.
(Continued below on page 185)

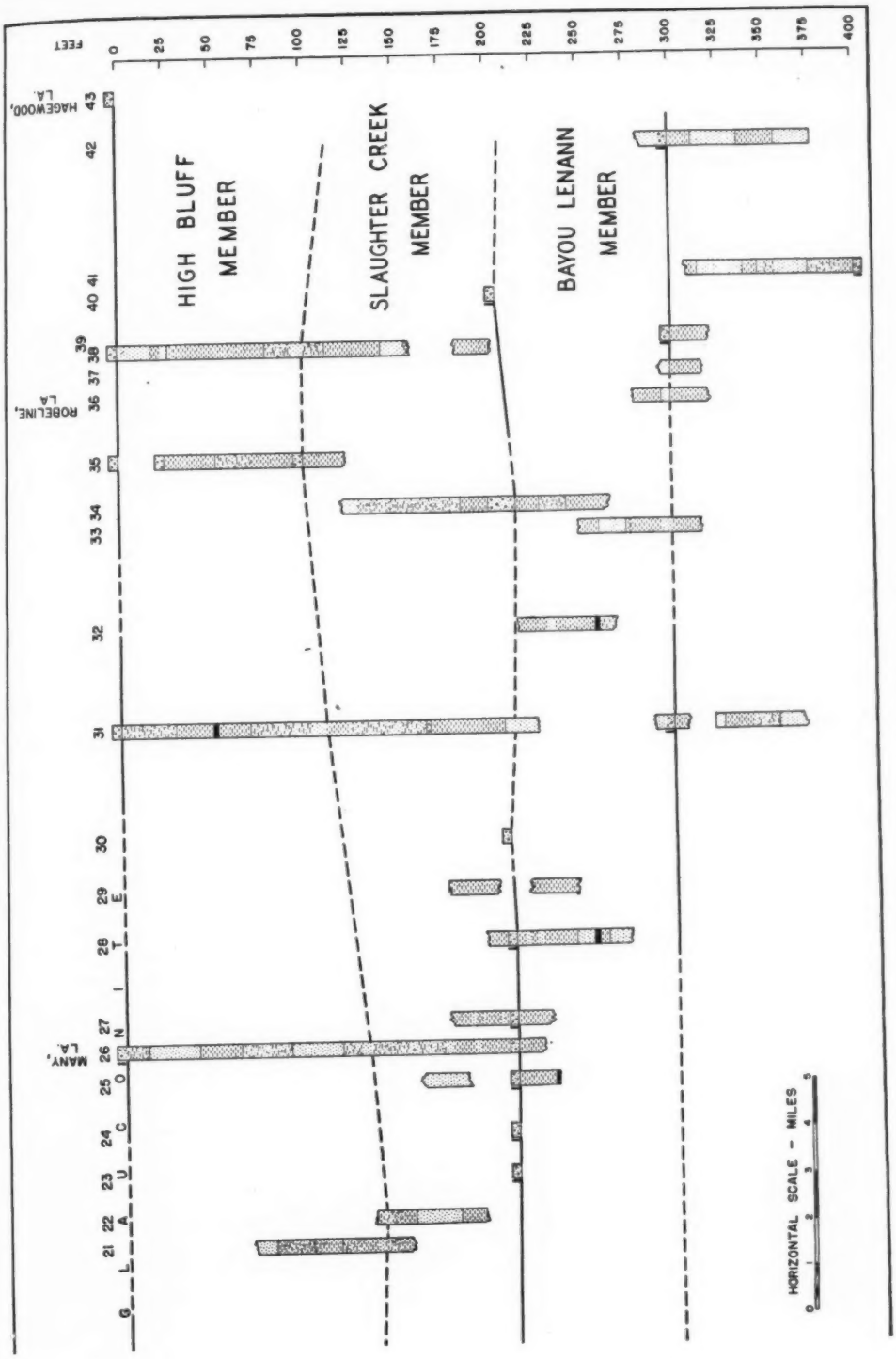

FIG. 4.—Continued

(Continued below on page 185)

ture of the Sabine uplift. The regional dip, measured from surface exposures is approximately 75 feet per mile and is everywhere away from the crest of the uplift. Subsurface studies show that a few miles south of the outcrop area, dip of the basal beds of the Sabine (Wilcox) group steepens to over 200 feet per mile and the overlying Sabine (Wilcox) section thickens more than 1,000 feet in 12 miles. The monocline associated with this increase in dip may have been connected with the doming of the Sabine uplift which Moody (1931) believes had its inception during lower Eocene time.

The sediments of the Pendleton formation are mainly nonmarine with a few interbedded shallow-water marine fossiliferous sands. The association of these types of sediments indicates deposition near the coastline of a deltaic plain and the thickness of the subsurface section south of the outcrop also denotes this type of deposition. Fisk (1941) believes that two main centers of lower Eocene (Wilcox) deltaic deposition were active in the Gulf Coast, one in the western Mississippi and eastern Louisiana region, and the other in east-central Texas. If such were the case, the Sabine River area during Wilcox time was located between two flanking deltas. This hypothesis is supported by the constant thickness of the formation, by the frequent and widespread occurrence of marine beds within the formation, and by the absence of thick channel sands which characterize deltaic centers.

The Pendleton formation is typically developed along Sabine, River but it is best exposed over a wide area drained by two Louisiana tributaries of this stream, Bayou Lenann and Slaughter Creek, and in this region of extensive exposures the formation has been subdivided into three members. These are (oldest to youngest) Bayou Lenann member, Slaughter Creek member, and High Bluff member.

Bayou Lenann member.—The Bayou Lenann member is typically exposed on Bayou Lenann, sec. 12, T. 6 N., R. 13 W., Sabine Parish, Louisiana (see loc. 8; also fig. 4, column 18). The outcrops at this locality are both in the stream bank and along the road leading to the stream. The following section is exposed:

Section on Bayou Lenann

Bayou Lenann member	Feet
Silts, lignitic, thin bedded	15
Sand	20
Silts, lignitic (Some thin sand beds)	45
Sand, fossiliferous, glauconitic, concretionary	10
Marthaville formation	
Clay, blocky, black to water level (contains microfossils, may have macrofossils below water level)	5

The basal bed of this member is a glauconitic, fossiliferous, marine sand. Concretions are present in its upper portion and are readily traceable over a large portion of the area of outcrop. Concretions are also present in the overlying 45 feet of lignitic silt and 20 feet of sand. The uppermost 15 feet of this member is very lignitic silt which may grade laterally into thin seams of lignite. The total thickness of the member is approximately 90 feet.

Slaughter Creek member.—The Slaughter Creek member is typically exposed along the banks of Slaughter Creek, Sabine Parish, Louisiana. An especially good section outcrops in a steep bluff near the headwaters of this stream in the southwest corner sec. 26, T. 6 N., R. 13 W., where the following section of the Slaughter Creek member is exposed (see also fig. 4, column 13):

Section on Slaughter Creek

Slaughter Creek member	Feet
Covered	10
Beulah Church glauconitic sand, sparingly fossiliferous	1
Silts, lignitic	6
Stone Coal Bluff lignite	0.5
Sand, locally cross bedded, with silt stringers	25
Clay, black, lignitic, locally fossiliferous	20
Sand, glauconitic, fossiliferous with pipe-like, limonitic nodules to water level	5

This member has a total thickness of about 60 feet. The basal glauconitic sand with abundant pipelike, limonitic nodules is the best mappable unit of the Pendleton formation. It is the basal fossiliferous bed exposed at Pendleton Ferry, and it is also well exposed on Slaughter Creek at localities 4 and 5. This sand is overlain locally by 15 to 20 feet of fossiliferous clay including at some places a sparingly fossiliferous glau-

conitic sand in its upper part. The overlying 20 feet of nonfossiliferous sand contains large calcareous concretions at many outcrops.

The Stone Coal Bluff lignite is named from its outcrop at Stone Coal Bluff on the Sabine River (see fig. 4, column 11). It varies in thickness from 1 to 6 feet, occupies a constant stratigraphic position, and has been traced for 14 miles along the strike of the formation.

The Beulah Church lentil is present at the base of 30 feet of lignitic silts, clays, and sandy silts lying above the lignite. It consists of 2 to 4 feet of glauconitic sparingly fossiliferous sand, it is well developed at the type locality of the Slaughter Creek member (see fig. 4, columns 11–16), but has been recognized only near Sabine River. The lignitic silts in the upper portion of the overlying beds grade laterally into thin seams of lignite.

High Bluff member.—The High Bluff member is typically exposed at High Bluff on Sabine River in an excellent outcrop first described by Veatch (1902). It attains a thickness of approximately 130 feet and its stratigraphic relations are shown on figure 4, column 12. At its base is a fossiliferous, glauconitic sand, four feet thick, the two best exposures of which are on the banks of Coal Mine Creek (loc. 1, fig. 5), and on the Many-Pendleton road (Louisiana Highway 6) near Beulah Church (loc. 2, fig. 5). This bed is not well known elsewhere, but a glauconitic, nonfossiliferous sand occupies a comparable stratigraphic position both east and west of the Sabine River area. The basal glauconite is succeeded by a widespread sand 10 feet thick containing flat, calcareous concretions. Above this occurs 65 feet of thin bedded lignitic silts and sands at High Bluff and a thin, lenticular bed of lignite is present near the top of this section. The uppermost portion of the High Bluff member consists of cross-bedded sands 25 to 30 feet thick, gradational with underlying beds, and deeply weathered to dense, limonitic sand blocks at the type locality, but extensive, fresh exposures occur across the Sabine River in Sabine County, Texas.

The upper sands of the Pendleton formation are overlain by the basal, glauconitic, sparingly fossiliferous sand of the Sabinetown faunal unit, the Pierson glauconite. This bed weathers to a red, ferruginous, sandy clay, which is easily recognized and traced over long distances.

STRATIGRAPHIC RELATIONS

The limits and divisions of the Pendleton formation were based on detailed stratigraphic and paleontologic studies made near Sabine River. Later, this formation and its members were traced westward across Sabine County, Texas and eastward to the Red River in Natchitoches Parish, Louisiana. Figure 4 shows diagrammatically the stratigraphic relationships, the outcrop thickness of each lithologic unit, and the lateral changes in the sediments of the Pendleton formation in eastern Texas and western Louisiana. The locations of the sections which were examined are shown in figure 3.

FAUNA

The marine beds of the Pendleton formation carry a fauna that can be distinguished from the faunas present in other parts of the Sabine (Wilcox) group. The fossils occur typically in glauconitic marine sands at the base of each of the lithologic members, and in certain other marine lentils within the Slaughter Creek member.

The larger fossils may occur as well preserved shells or as casts or molds. The casts in slightly weathered sands are commonly inclosed in ironstone concretions. Foraminifers, ostracodes, and a restricted molluscan fauna occur in the clays which locally overlie the basal marine sand of the Slaughter Creek member.

Figure 5 shows the geographic distribution of the known fossil localities of the Sabine (Wilcox) group in the Sabine area. Detailed locality descriptions of the best fossiliferous outcrops are included in the locality list at the end of this paper, and their faunas are presented on the check list.

The usual Tertiary invertebrate fossil groups are represented in the Pendleton formation. A number of species of the foraminiferal genera *Ammobaculites*, *Haplophragmoides*, *Robulus*, *Nonion*, *Bulimina*, *Uvigerina*, *Globulina*, *Anomalina*, and *Discorbis*, are present but most of the species are undescribed. Ostracodes are common, but it is

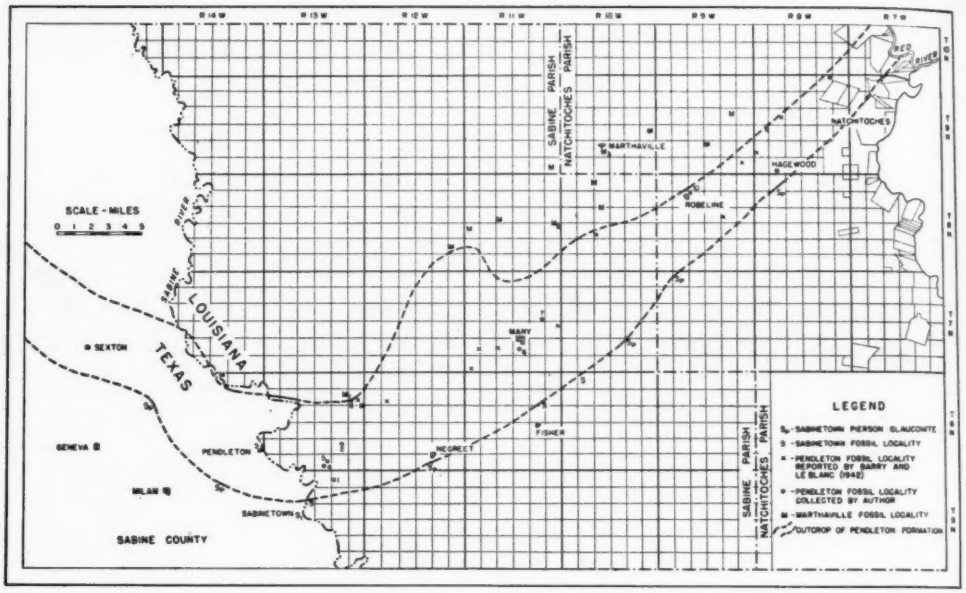

FIG. 5—Fossil localities of the Pendleton formation in eastern Texas and western Louisiana.

beyond the scope of this paper, however, to establish the value of these microfossils for detailed correlation. They may prove to be of considerable stratigraphic importance in surface and subsurface studies, and should be made the object of further study.

Cephalopods and echinoids are rare, and therefore of little value in the field recognition of zones.

Pelecypods, gastropods, and corals are the most abundant and characteristic fossils of the formation, and are the basis of the correlations herein discussed.

The Pendleton assemblage is so closely related to the Tuscahoma fauna of Alabama that there appears to be no doubt of their equivalence. *Turritella praecincta*, *Nuculana corpulentoidea*, and *Fissurella alabama* are all

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EXPLANATION OF PLATE 31

FIGS. *1*—*Ostrea multilirata* Conrad. Exterior of right valve (L. S. U. Paleo. Mus. hypotype 5115), loc. 30 of Barry and LeBlanc (6), ×0.5.

2—*Ostrea thirsae* (Gabb). Exterior of right valve (L. S. U. Paleo. Mus. hypotype 5603), loc. M_1, ×1.3.

3—*Haimesiastraea conferta* Vaughan. (L. S. U. Paleo. Mus. hypotype 5602), loc. M_1, ×2.7.

4—*Cardium toumeyi* Aldrickh *var.* Exterior of left valve (L. S. U. Paleo. Mus. hypotype 5188), loc. 1, ×1.

5—*Turritella mortoni postmortoni* Harris. Apertural view (L. S. U. Paleo. Mus. hypotype 6017) Specimen from Bell's Landing on the Alabama River, Alabama, ×0.95.

6—*Nuculana corpulentoidea* (Aldrich). Exterior of right valve (L. S. U. Paleo. Mus. hypotype 5065), loc. 3, ×2.4.

7—*Turritella praecincta* Conrad. Apertural view (L. S. U. Paleo. Mus. hypotype 5605), loc. 5, ×1.2.

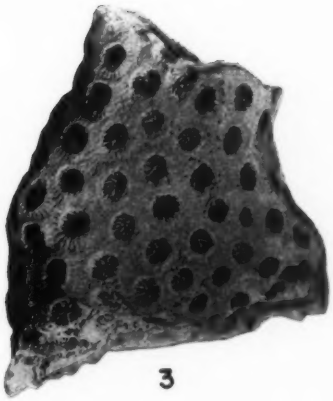
8—*Venericardia densata pendletonensis* Gardner and Bowles. Exterior of left valve (L. S. U. Paleo. Mus. hypotype 5601), loc. 5, ×1.2.

9—*Venericardia bashiplata* Gardner and Bowles. Exterior of right valve (L. S. U. Paleo Mus. hypotype No. 4996), Woods Bluff, Alabama, ×0.86.

10—*Venericardia sabinensis* Barry. Exterior of left valve (L. S. U. Paleo. Mus. topotype 5604), loc. 1, ×1.2.

1

2



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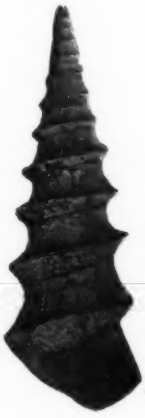

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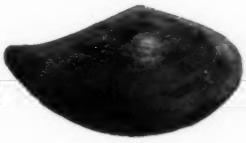

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7

8

9

10

restricted to the Tuscahoma in Alabama and to the Pendleton in Louisiana. Numerous other species, such as *Turritella mortoni postmortoni, Calyptraphorous trinodiferus, Hemisurcula silicata, Levifusus supraplanus,* etc., are common to both formations, though not restricted to either one. Approximately 65 per cent of the Pendleton species have been reported from the Tuscahoma.

Index species.—Certain molluscan genera, because of their rapid evolution and widespread occurrence have long been used for correlation purposes in the Gulf Coast. Foremost among these are *Ostrea, Venericardia,* and *Turritella.*

Species of these genera are among the most diagnostic and characteristic fossils of the Sabine (Wilcox) in the Sabine uplift area. These species are: *Ostrea thirsae, O. multilirata, Venericardia densata pendletonensis, V. sabinensis, V. bashiplata, Turritella mortoni postmortoni,* and *T. praecincta.*

In addition, work in the Sabine area has shown the important stratigraphic value of three other fossils, namely *Nuculana corpulentoida, Cardium toumeyi* var., and *Haimesiastraea conferta.*

Enough is known about the occurrence of these species, either from the observations by the authors, or from the work of Barry and LeBlanc (1942) to establish their ranges. Their stratigraphic relationships are shown on figure 6,[4] and they are illustrated on plate 31.

ZONES OF THE PENDLETON FORMATION

Three of the previously mentioned characterizing species of the Sabine (Wilcox) group exhibit peculiarities in their teilzones[5] which make it possible for them to be used as index species for three biostratigraphic zones in the Pendleton formation.

The zones are:

Cardium toumeyi zone—Bayou Lenann member.

Nuculana corpulentoidea zone—Slaughter Creek member.

Venericardia sabinensis zone—High Bluff member.

Cardium toumeyi zone.—The *Cardium toumeyi* zone occupies a very limited stratigraphic thickness, not exceeding 12 feet, at the base of the Bayou Lenann member. It can be traced definitely from Sabine to Red River.

This zone has several diagnostic features. *Cardium toumeyi,* which ranges from somewhere in the Marthaville to the top of the Pendleton, occurs abundantly, comprising nearly three-fourths of the fauna. There is a notable absence of the smaller mollusca usually present in the Pendleton fossil beds. Also, in contrast to the usual occurrence of fossils in this region the fauna of the *Cardium* zone is widely scattered through the glauconitic sand, and is not concentrated in fossiliferous lenses.

Nuculana corpulentoidea zone.—This zone occupies the basal portion of the Slaughter Creek member and includes the fossiliferous beds at Pendleton Ferry (loc. 3). Marine lentils occur stratigraphically above the Pendleton Ferry beds in the vicinity of the Sabine River and the zone is expanded to include these lentils, for their fauna is indistinguishable from that of the persistent bed below (see fig. 6).

The *Nuculana corpulentoidea* zone may be recognized by the following criteria:

1. It is definitely identified by the presence of *N. corpulentoidea* or *Turritella praecincta,* both of which are restricted to this zone.

2. Its varied fauna distinguishes it from the *Cardium* zone.

3. The presence of *Venericardia densata pendletonensis* also distinguishes it from fossiliferous beds of the High Bluff member.

Venericardia sabinensis zone.—The fossiliferous beds at the base of the High Bluff member comprise the *Venericardia sabinensis* zone which has been recognized only in the Slaughter Creek area. In spite of its apparent limited areal extent, this zone is a distinctive unit, and it is of unquestionable local stratigraphic value. It can be distinguished readily by the presence of *V. sabinensis* (usually very abundant) and by the absence of *V. densata pendletonensis,* so

[4] The range of individual species is extended through the nonmarine beds to the top of a member if the species occurs in the uppermost fossilferous bed of that member. Such arbitrary extension is indicated by a dashed line on figure 6.

[5] Teilzone refers to the complete range of a species in any local area. For a thorough discussion of teilzone, zone, etc., see Arkell (1933).

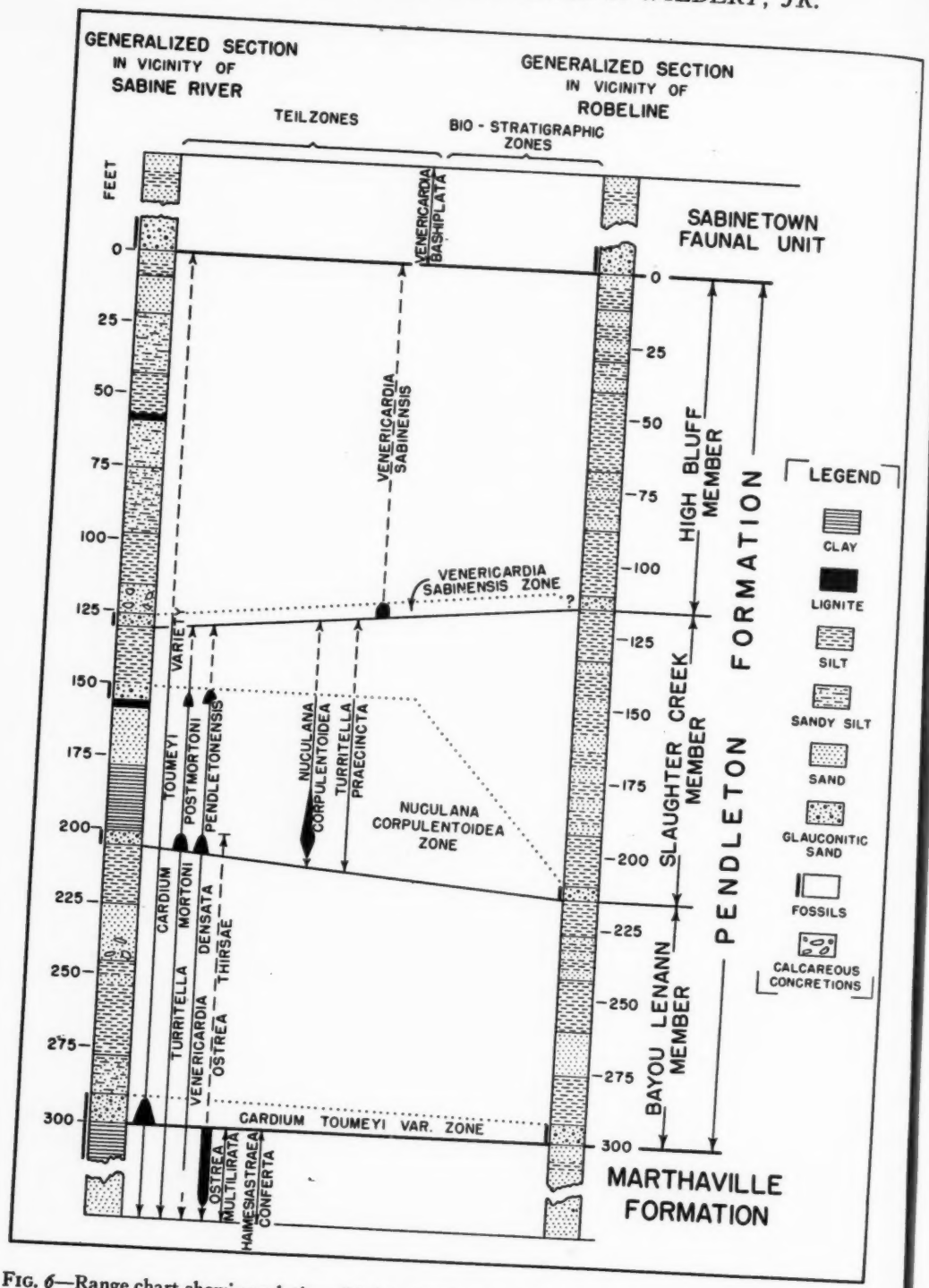

FIG. 6—Range chart showing relation of Sabine (Wilcox) species to those in the Pendleton formation.

characteristic of the other Pendleton horizons.

SUMMARY AND CONCLUSIONS

1. The establishment of the Pendleton formation as a definite mappable unit of the lower Eocene (Wilcox) group permits more accurate differentiation of this comparatively little studied group of thick deltaic sediments.

2. The fact that these beds have been traced for approximately 50 miles along the strike demonstrates their widespread distribution and suggests the probability that this formation and its members may be recognized in subsurface studies.

3. The presence of diagnostic fossils in the marine beds of the Pendleton formation permits the zoning of the sediments and substantiates the regional correlations made by earlier authors.

DESCRIPTION OF LOCALITIES[6]

Sabinetown Formation

S_1 (L. S. U. Paleo. Mus. Loc. No. 1777)—Bluff ½ mile downstream from Sabinetown Ferry, on the Sabine River, Sabine County, Texas.

Pendleton Formation

High Bluff Member

1 (L. S. U. Paleo. Mus. Loc. No. 1767)—Stream bank in NW cor., NW¼, SW¼, sec. 3, T. 5 N., R. 13 W., Sabine Parish, Louisiana. Fossils collected from bluish gray or oxidized brown glauconitic sands. Locality 41 of Barry and LeBlanc (1942).

2 (L. S. U. Paleo. Mus. Loc. No. 1859)—In roadcut of Louisiana Highway 6, 50 yds. west of intersection with local road to south, W½, NE¼, sec. 26, T. 6 N., R. 13 W., Sabine Parish, Lousiana. Numerous casts (principally *Venericardia sabinensis*) collected from glauconitic sand near top of the roadcut.

Slaughter Creek Member

3 (L. S. U. Paleo. Mus. Loc. No. 1766)—About ½ mile upstream from bridge (on Louisiana Highway 6) over Sabine River, Sabine County, Texas. This is the Pendleton Ferry locality of Harris and Veatch (1899).

4 (L. S. U. Paleo. Mus. Loc. No. 1860)—In stream bed of Slaughter Creek, just off Mr. Ben Sibley's field, NW¼, SE¼, sec. 34, T. 6 N., R. 13 W., Sabine Parish, Louisiana. Well preserved mollusks in glauconitic sand, outcropping continuously for about 100 yards in the stream bottom or on the adjacent banks.

5 (L. S. U. Paleo. Mus. Loc. No. 1861)—On stream bank, 250–300 yards. above locality 4, on small southwest flowing tributary of Slaughter Creek, NW¼, NE¼, SE¼, sec. 34, T. 6 N., R. 13 W., Sabine Parish, Louisiana. Well preserved mollusks.

6 (L. S. U. Paleo. Mus. Loc. No. 1862)—On old abandoned road where it approaches Tar River, ¼ mile south of Many, in center NE¼, SW¼, sec. 27, T. 7 N., R. 11 W., Sabine Parish, Lousiana. Numerous casts in oxidized glauconitic sand at about middle of slope.

7 (L. S. U. Paleo. Mus. Loc. No. 1775)—Road cut along Louisiana Highway 6 at intersection with local road in SE¼, sec. 14, T. 7 N., R. 11 W., Sabine Parish, Louisiana. Impressions and molds found in glaucontic ferruginous sand. Locality 52 of Barry and LeBlanc (1942).

Bayou Lenann Member

8 (L. S. U. Paleo. Mus. Loc. No. 1771)—South bank of Bayou Lenann, about 100 yards, upstream from bridge on local road in center of sec. 12, T. 6 N., R. 13 W., Sabine Parish, Louisiana. Collection from fossiliferous, glauconitic, yellowish-brown, fine sand, about 12 feet above dark gray, thinly bedded, jointed, silty clays near water level. Locality 46 of Barry and LeBlanc (1942?).

9 (L. S. U. Paleo. Mus. Loc. No. 1863)—Stream bank of north flowing tributary of Bayou Lenann, about 400 yards from its junction with Bayou Lenann, in about middle of the W½, SW¼, sec. 12, T. 6 N., R. 13 W., Sabine Parish, Louisiana. Fossils collected from glauconitic, fine sand.

10 (L. S. U. Paleo. Mus. Loc. No. 925)—Hillside in extreme NE¼, SW¼, NW¼, sec. 9, T. 8 N., R. 9 W., Natchitoches Parish, Louisiana. Hill is about 75 yards north of Louisiana Highway 6. Impressions found in yellowish-brown, limonitic, fine sand. Locality 55 of Barry and LeBlanc (1942).

Marthaville Formation

M_1 (L. S. U. Paleo. Mus. Loc. No. 1864)—Stream bank of north flowing tributary of Bayou Lenann, about 325 yards from its junction with Bayou Lenann, 75 yards downstream from locality 9, in W½, SW¼, sec. 12, T. 6 N., R. 13 W. Sabine Parish, Louisiana. Well preserved fossils in pockets in massive clay.

M_2 (L. S. U. Paleo. Mus. Loc. No. 1760)—Stream bed on Riaine's place in NE¼, NE¼, sec. 24, T. 8. N, R. 11 W., Sabine Parish, Louisiana. This is the Rocky Springs Church Locality of Harris and Veatch (1899), p. 63. *Ostrea multilirata* Conrad and other species collected from a calcareous silty ledge. (Locality 32 of Barry and LeBlanc (1942?).)

M_3 (L. S. U. Paleo. Mus. Loc. No. 1752)—Roadcut at Marthaville in center of SE¼, sec. 28, T. 9 N., R. 10 W., Natchitoches Parish, Louisiana. Impressions found in ferruginous concretion. Locality 22 of Barry and LeBlanc (1942.)

[6] Only those localities which exhibit good representative faunas are given locality numbers and listed here.

PENDLETON SPECIES FROM LOCALITIES LISTED ON PAGE 191

	Sabinetown	Pendleton										Marthaville		
		Members												
		High Bluff		Slaughter Creek					Bayou Lenann					
	S_1	1	2	3	4	5	6	7	8	9	10	M_1	M_2	M_3
ANTHOZOA														
Madracis gregorioi Vaughan				o	x	x						x		
Haimesiastraea conferata Vaughan												x		
ECHINOIDEA														
Linthia hollandi Barry				o										
PELECYPODA														
Nucula ovula Lea	o			o	x									
Nuculana corpulentoidea (Aldrich)				x	x	x		x						
Nuculana corpulentoidea var.												x		
Nuculana sp.		o												
Nuculana aldrichiana var. *sabinetownensis* Barry	o													
Yoldia sp.							x	x				x		
Trinacria microcancellata Barry	o													
Arca (*Barbatia*) *cuculloides ludoviciana* Harris	o			x	x	x	x	x				x		
Ostrea thirsae (Gabb)				o				x				x		o
Ostrea multilirata Conrad													o	
Ostrea sp. cf. *O. compressirostra* Say					x	x								
Modiolus (*Brachidontes*) *stubbsi* Harris													o	
Modiolus (*Brachidontes*) *alabamensis* Aldrich				x								x		
Modiolus (*Modiolus*) sp.									o					
Periploma howei Barry				x										
Venericardia (*Venericor*) *densata pendletonensis* Gardner & Bowles				x	x	x	x	x			o			
Venericardia (*Venericor*) *sabinensis* Barry		x	x											
Venericardia (*Venericor*) *sabinensis* var.												x		
Lucina? sp.				x	x									
Phacoides (*Parvilucina*) *sabelli* Gardner	o			o										
Cardium (*Cerastoderma*) *toumeyi* Aldrich var.		o	x	x	x	x		x	o	x	o			
Pitaria (*Pitaria*) *nuttalopsis greggi* (Harris)		o	x	x	x	x	x	x	o	x	o			
Macrocallista triangulata Barry	o													
Tellina bellsiana Aldrich		o												
Tellina sp. Barry				x					o		o			
Tellina sp. cf. *T. semipapyra* Aldrich	o													
Solen pendletonensis Barry				x							o			
Spisula parilis bistriata (Harris)	o													
Corbula (*Caryocorbula*) *aldrichi* Meyer				x	x	x	x	x						
Corbula (*Caryocorbula*) *cappa* Barry	o	o		o										
Corbula sp.												x		
CEPHALOPODA														
Aturia (*Brazaturia*) species (Stenzel MS)				o										
SCAPHOPODA														
Cadulus (*Dischides*) *abruptus* Meyer & Aldrich	o													
GASTROPODA														
Teinostoma barryi LeBlanc	o													
Fissurella alabama Harris					x									
Skenea sylvaerupis (Harris)	o													
Skenea dalli (Harris)	o													
Tuba antiquata (Conrad)	o													

PENDLETON SPECIES (*Continued*)

	Sabinetown	Pendleton										Marthaville		
		Members												
		High Bluff		Slaughter Creek					Bayou Lenann					
	S_1	1	2	3	4	5	6	7	8	9	10	M_1	M_2	M_3
Melanella wheeleri Palmer	o													
Solariella sp.												x		
Architectonica bellense (Harris)	o			o										
Epitonium multiliniferum Aldrich	o			o										
Epitonium exquisita (Aldrich)												x		
Ampullina alabamiensis (Whitfield)				x										
Natica aperta Whitfield				x	x		x	x			o	x		
Natica (*Sigaticus*) *clarkeana* (Aldrich)	o													
Polinices harrisii Gardner					x	x								
Atys robustoides Aldrich						x						x		
Turritella eurynome Whitfield				o										
Turritella praecincta Conrad				o		x								
Turritella bellifera Aldrich				o	x	x		x						
Turritella mortoni postmortoni Harris				x	x	x		x			o			
Turritella sp.												x		
Mesalia sp. cf. *M. alabamiensis* (Whitfield)					x	x								
Bittium (*Stylidium*) *anita* Aldrich	o													
Cerithiella terebropsis (Harris)	o													
Calyptraphorus trinodiferus Conrad	o			x	x	x						x		
Galeodea (*Mambrinia*) *koureos* Gardner				x		x								
Priscoficus (*Fulguroficus*) *juvenis* (Whitfield)	o			o										
Tritonidea pachecoi Harris				o										
Cancellaria sp.					x									
Turbinella (*Glyptostyla?*) *baculus* Aldrich?						x								
Mazzalina plena Aldrich?				o										
Olivella mediava Harris												x		
Pseudoliva vetusta (Conrad)				x	x	x				x				
Pseudoliva tuberculifera Conrad												x		
Buccinanops ellipticum Whitfield	o			o	x	x	x							
Buccitriton sagenum (Conrad)	o			o										
Nassarius exilis (Conrad)	o			x	x	x	x	x						
Levifusus supraplanus Harris				x	x									
Levifusus trabeatus (Conrad) var. Harris	o			o										
Levifusus indentus Harris				x	x				o			x		
Levifusus indentus Harris var.								x						
Levifusus pagoda (Heilprin)				x	x	x		x		x		x		
Papillina? sp.												x		
Cornulina minax (Solander)		x		x										
Latirus sp.								x				x		
Voluta newcombiana Whitfield				o		x								
Athleta petrosa (Conrad)	o			x	x	x		x						
Volutacorbis sp.												x		
Turricula nasuta (Whitfield)				o				x						
Turris sp. cf. *T. bimoniatus* Aldrich	o													
Turris sp.												x		
Turris nodoideus Aldrich	o													
Orthosurcula longipersa (Harris) var.												x		
Trigonostoma sabinetownensis LeBlanc	o													
Hemisurcula silicata (Aldrich)				o	x	x	x					x		
Pleurotoma capax Whitfield		o												
Pleurotomella veatchi Harris		o		o		x								o
Bullinella sylvaerupis (Harris)	o													
Dorsanum scalatum (Heilprin)				o										

PENDLETON SPECIES (*Continued*)

	Sabinetown	Pendleton										Marthaville		
		Members												
		High Bluff		Slaughter Creek					Bayou Lenann					
	S_1	1	2	3	4	5	6	7	8	9	10	M_1	M_2	M_3
OSTRACODA														
Cytheridea robertsi Howe & Garrett	*													
Cytheridea spooneri Howe & Garrett	*													
Eocytheropteron sabinensis Howe & Garrett	*													
Cythereis harrisi Howe & Garrett	*													
Cythereis sabinensis Howe & Garrett	*													
Cytheridea broussardi Howe & Garrett	*													
Cytheridea moodyi Howe & Garrett	*	x		*	x	x						x		*
Cytheridea veatchi Howe & Garrett	*	x		*	x	x								
Cytheridea wallacei Howe & Garrett	*	x										x		*
Cythereis ? alabamensis Howe & Pyeatt	*	x			x	x						x		*
Cythereis hilgardi Howe & Garrett	*				x	x								
Orthonotacythere sabinensis Howe & Garrett				*	x									
Cytherelloidea nanafaliensis Howe				*	x							x		
Cytheridea pendletonensis Howe & Garrett				*	x									
Cytheridea ? pyeatti Howe & Garrett		x		*	x									*
Cytheridea sabinensis Howe & Garrett				*	x							x		*
Cytheridea hopkinsi Howe & Garrett				*								x		
Cytheridea marthavillensis Howe & Garrett												x		
Cytherelloidea veatchiana Howe												x		
Cytherelloidea tombigbeensis Howe												x		
Cytheridea leei Howe & Garrett												x		
Brachycythere jessupensis Howe & Garrett												x		
Cytheridea ? jessupensis Howe & Garrett												x		

x—In authors' collection.
o—Reported by Barry & LeBlanc (1942).
*—Reported by Howe & Garrett (1934).

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PACIFIC COAST CRETACEOUS AND TERTIARY CORALS

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ABSTRACT—*Balanophyllia cowlitzensis, Deltocyathus whitei, Flabellum californicum* var. *fiedleri, F. fresnoense, F. oregonense, Platycyathus grahami, Platytrochus diabloensis* are described as new. *Flabellum remondianum* Vaughan (not Gabb) is renamed *F. stantoni*. The occurrence of *Cyclolites?* n. sp. *Flabellum?* sp., and *Dendrophyllia oldroydi* Faustino is recorded. *Flabellum remondianum* Gabb appears to be confined to basal Martinez (Paleocene) strata.

FEW CORALS have been described from the late Cretaceous and Tertiary beds of the Pacific Coast, the most important papers being those of Durham (1942), Nomland (1916, 1917), Quayle (1932), and Vaughan (1900, 1917). A few species have been described incidentally in other papers.

Although the coral fauna of the lower and middle Eocene formations has been incompletely studied, more species and individuals are known from those strata than from all the remainder of the Tertiary. It is probable that extensive and careful collecting from the Tertiary will yield many more species of solitary corals and that in favorable situations, such as at the base of transgressing strata, coral reefs will be found. Of the 12 species and one variety here discussed, one is from the upper Cretaceous, one from the late Pliocene or Pleistocene, one from the Oligocene, one from the upper Eocene and the remainder from the Paleocene, lower Eocene and middle Eocene.

Numbers, unless otherwise noted, refer to the University of California collections and register of localities.

SYSTEMATIC DESCRIPTIONS

Genus FLABELLUM Lesson

Flabellum LESSON, *1831*, Illust. de Zool., pl. 14.

Genotype, *Flabellum pavoninum* Lesson.

FLABELLUM CALIFORNICUM Vaughan

Flabellum californicum VAUGHAN, *1900*, U. S. Geol. Surv. Mon. 39, p. 69, pl. IV, figs. 11–12. NOMLAND, *1916*, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 9, p. 60, pl. 4, figs. 14, 15, 16.

Types.—Hypotypes nos. 12034, 12035.

Occurrence.—Beds of Domengine age near Clayton, California.

Remarks.—This species is readily distinguished from mature individuals of *F. remondianum* Gabb by the presence of only 48 septa of which there are 12 heavy major members.

FLABELLUM CALIFORNICUM var. FIEDLERI Durham, n. var.

Plate 32, figure 18

Corallum moderately large, tall, base broken; cross-section compressed, elliptical; septa in four cycles with a few of the fifth present, apparently those of first three cyles reach columella; costae indistinct, covered by a wrinkled epitheca with irregular girdling depressions; in cross section made 9 mm. below calyx, calicular fossa is apparently very narrow and deep, columella not showing in this section.

Dimensions.—Height (base broken) 28.7 mm.; long diameter of calyx 19.8 mm.; short diameter of calyx 9.3 mm.

Type.—Holotype no. 30095, loc. A 3824, fossiliferous sandstone in center NE¼ SW¼ sec. 25, T. 18 S., R. 2 E., Jamesburg Quadrangle, California. Middle Eocene, Domengine stage.

Remarks.—This variety may be distinguished by its large size and height. It is associated with *Discocyclina* sp., a small *Venericardia* and *Nemocardium linteum* (Conrad).

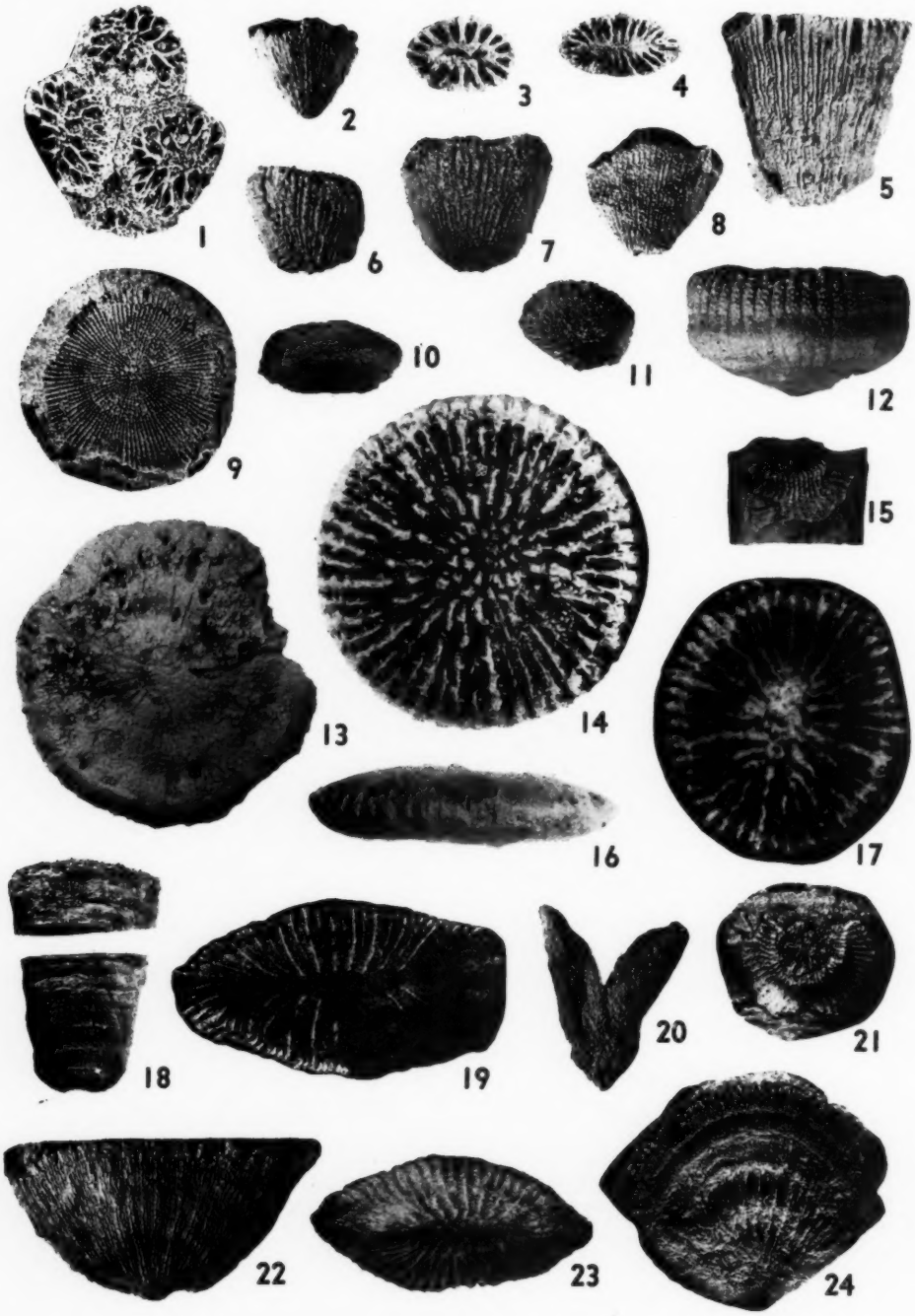
FLABELLUM REMONDIANUM Gabb

Plate 32, figures 4, 8

Flabellum remondianum GABB, *1864*, Geol. Surv. California., Paleontology, vol. 1, p. 207, pl. 26, fig. 199. DICKERSON, *1914*, Univ. California Publ., Bull. Dept. Geol. Sci., vol. 8, p. 151, pl. 6, figs. 1a, 1b, 1c, 1d.

Not *Flabellum remondianum* VAUGHAN, *1900*, U. S. Geol. Surv. Mon. 39, pp. 67–68, pl. IV, figs. 5–6.

Corallum of medium size, cuneate, moderately flattened, with a small pedicle; cross



Durham, Cretaceous and Tertiary Corals

section elliptical; ten major septa on each side of calix extending to columellar fossa; secondary and tertiary septa of much smaller size in interspaces, making a total of 80 septa; inner ends of major septa thickened, apparently joining columella deep within calix; septa about one-half as wide as their interspaces; columellar fossa deep, narrow, elongate; wall covered by polished epitheca; costae indistinct beneath epitheca; surface of epitheca with 8 to 12 indistinct radiating ridges or pseudocostae.

Dimensions.—Hypotype no. 11846, height 18.2 mm., greatest diameter 17.7 mm., lesser diameter 10.7 mm.

Types.—Holotype, whereabouts unknown; hypotypes 11846 (loc. 1743), 12434 (loc. 1743), 12029 (loc. 1556), no. 30092 (loc. A 1621), all from localities within 20 feet of the base of the Martinez formation on the Mount Diablo Quadrangle, California; Stanford Univ. Paleo. Type Coll., hypotype 6547 is from L.S.J.U. loc. 2073, Lodo formation (see *Deltocyathus whitei* for locality description), Paleocene.

Occurrence.—From the records available this species appears to be confined to the basal Martinez stage, Paleocene.

Remarks.—This species may be distinguished from *F. californicum* Vaughan by the presence of 20 major septa and a total of 72 septa, with the major septa much thinner than in Vaughan's species. The specimen from L.S.J.U. loc. 2073 (pl. 32, figs. 4, 8), apparently represents only the lower half of a young individual whose septa are fewer in number.

Although the whereabouts of Gabb's type of this species is unknown, the specimens figured by Dickerson come from the same general area as the type and some of them may be presumed to be topotypes. Additional material from the same area presents the same characters; both Dickerson's specimens and the new material agree roughly with Gabb's poor figures, whereas the specimens figured by Vaughan do not correspond at all.

FLABELLUM FRESNOENSE Durham, n. sp.
Plate 32, figures 2, 3

Corallum small, cuneate, only slightly

EXPLANATION OF PLATE 32

FIGS. *1*—*Dendrophyllia oldroydi* Faustino? ×1.6. Hypotype no. 30107, loc. A 3770. Late Pliocene or Pleistocene. (p. 201)

2–3—*Flabellum fresnoense* Durham, n. sp. ×2. Holotype, Stanford Univ. Paleo. Type Coll. no. 7374, depth 5,800 feet, Cheney Well no. 1, Fresno County, California. Upper Cretaceous. (p. 197)

4, 8—*Flabellum remondianum* Gabb ×2. Hypotype, Stanford Univ. Paleo. Type Coll. no. 6547, L.S.J.U. loc. 2073. Lodo Formation, Paleocene. Specimen broken at about half height of corallum. (p. 196)

5—*Flabellum?* sp. ×2. Hypotype, Stanford Univ. Paleo. Type Coll. no. 6545, loc. 2073. Lodo Formation, Paleocene. (p. 199)

6, 7, 10, 11, 17—*Platytrochus diabloensis* Durham, n. sp. ×2.2. *6, 11*, paratype no. 30064, *7, 10*, holotype no. 30060, *17*, paratype no. 30078, cross section of round variant, poorly preserved, retouched, loc. A 3872. Domengine stage, Eocene. (p. 199)

9—*Cyclolites?* n. sp. ×2. Hypotype no. 30082, loc. A 3821. Domengine stage, Eocene. Mold of lower surface. (p. 201)

12, 14—*Platycyathus grahami* Durham, n. sp. ×3. Holotype no. 30097. ?Martinez Stage, Paleocene. (p. 200)

13, 16—*Deltocyathus whitei* Durham, n. sp. ×3. Holotype, Stanford Univ., Paleo. Type Coll. no. 6546, L.S.J.U. loc. 2073. Lodo Formation, Paleocene. Basal view. (p. 200)

15, 21—*Balanophyllia cowlitzensis* Durham, n. sp. ×1.6. Holotype no. 30090, loc. 7162. Cowlitz formation, upper Eocene. Side of corallum broken. (p. 201)

18—*Flabellum californicum* var. *fiedleri* Durham, n. var. ×1. Holotype no. 30095, loc. A 3824 Domengine stage?, Eocene. (p. 196)

19, 20, 23, 24—*Flabellum oregonense* Durham, n. sp. *19*, ×1.4. paratype no. 30118, incomplete cross section below calix; *20*, ×1.3, paratype no. 30120, vertical section. *23*, ×1.3, holotype no. 30117, basal view of internal mold; *24*, ×1.4, holotype loc. A 3669, Oligocene, external mold. (p. 198)

22—*Flabellum stantoni* Durham, n. name ×1.9, hypotype no. 30098, loc. 7000. Upper Santa Susana formation, lower Eocene. (p. 199)

flattened, partially decorticated, calix broken; cross section ovate; 16 subequally developed septa extending to flattened columella; remaining septa (8) of third cycle just noticeable in the four central interspaces of each side; primary septa about one-third as wide as their interspaces; septal faces sparingly granulated; columella flattened in plane of long axis of calyx, formed by trabecular fusion of inner ends of primary septa; wall formed by fusion of outer ends of primary of septa; epitheca apparently destroyed, leaving surface marked by heavy low ridges corresponding to septal interspaces with narrow grooves corresponding to septa.

Dimensions.—Height (broken) 7.4 mm., greater diameter of calyx 7.9 mm., lesser diameter 5.7 mm.

Types.—Holotype, Stanford Univ. Paleo. Type Coll. 7374, from a depth of 5,800 feet in Cheney 1, SW¼ sec. 29, T. 14 S., R. 13 E., Fresno County, California. Cretaceous.

Remarks.—Apparently this is the first *Flabellum* to be recorded from the Cretaceous. Except for the ridge formed by the outer edge of the primary septa at each end of the calyx there is no angulation of the corallum.

This species is associated with *Arrhoges* sp. and *Euspira shumardiana* (Gabb.) According to Lois T. Martin (personal communication), 80 feet higher stratigraphically, at a depth of 5,720 feet the following foraminiferal assemblage is found:

Anomalina ammonoides (Reuss)
Bathysiphon sp.
Bulimina brevis d'Orbigny
Dentalina megalopolitana Reuss
Epistomina caracolla (Roemer)
Eponides haidingerii (d'Orbigny)
Globigerina cretacea d'Orbigny
Gümbelina cf. globulosa (Ehrenberg)
Gyroidina globosa (V. Hagenow)
Haplophragmoides eggeri Cushman
Lenticulina navicula (d'Orbigny)
Lenticulina williamsoni (Reuss)
Nodosaria affinis Reuss
Robulus macrodiscus (Reuss)
Robulus munsteri (Roemer)
Robulus pseudo-secans Cushman
Silicosigmoilina californica Cushman and Church
Spiroplectoides clotho (Grzybowski)
Vaginulina sp.
"Valvulineria pachecoensis"

Between the depths of 5,827 and 5,834 feet the following foraminiferal assemblage is found:

Anomalina ammonoides (Reuss)
Bathysiphon sp.
Dentalina megalopolitana Reuss
Ellipsonodosaria alexanderi Cushman
Eponides haidingerii (d'Orbigny)
Eponides exigua (H. B. Brady)
Haplophragmoides eggeri Cushman
Lenticulina navicula (d'Orbigny)
Marginulina cf. ensis Reuss
Nodosaria nuda Reuss
Pseudoglandulina manifesta (Reuss)
Robulus pseudo-secans Cushman
Silicosigmoilina californica Cushman and Church
Spiroplectoides clotho (Grzybowski)
Vaginulina cf. simondsi Carsey
"Valvulineria pachecoensis"

FLABELLUM OREGONENSE Durham, n. sp.
Plate 32, figures 19, 20, 23, 24

Corallum moderately large, low, triangular, sides of calice highly arched; cross section compressed, elliptical; septa about 48 on a side, of which only about 12 reach columellar fossa, the second twelve reach nearly to fossa, narrow septa of fifth cycle present in interspaces; septal edges smooth, gradually rounding into deep columellar fossa; major septa thin, about one-fifth as wide as their interspaces; septal faces with fine ridges running from wall inwards and upwards at angle of about 60 degrees with wall; concentric ridges parallel to inner edge of septa; granules on septal faces in moderate numbers; wall destroyed on all specimens at hand but its mould shows it was ornamented by about 12 moderately prominent costae at about middle of corallum, epitheca above wrinkled parallel to upper edge of calyx; calyx with lateral edges very low, highly arched in center.

Dimensions.—Holotype (base broken), height (estimated) 20 mm.; greatest diameter of calix 27 mm.; lesser diameter 14 mm.

Types.—Holotype no. 30117, paratypes nos. 30118, 30119, 30120, all from loc. A 3669 (glauconitic sandstone, apparently on the road from Clatskanie to Mist, Columbia County, Oregon, sec. 19, T. 7 N., R. 4 W., Willamette base and meridian).

Age.—Lower Oligocene, equivalent in age to the Pittsburg Bluffs, Oregon, locality. It is associated with the same molluscan fauna as is found at the last named locality.

Remarks.—There are 12 more or less frag-

mentary specimens in the collection, associated with a well preserved molluscan fauna in a glauconitic sandstone matrix. The collection was mislaid for some time in the University of California collections and the original locality data lost. The present locality identification has been made on the basis of the lithology and the associated fossils which are numerous, characteristic of the area and age and well preserved.

FLABELLUM STANTONI Durham, n. name
Plate 32, figure 22

Flabellum remondianum, VAUGHAN, *1900*, U. S. Geol. Survey Mon. 39, pp. 67–68, pl. 4, figs. 5–6.

Not *Flabellum remondianum* GABB, *1864*, Geol. Surv. California Paleontology, vol. 1, p. 207, pl. 26, fig. 199; DICKERSON, *1914*, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 8, p. 151, pl. 6, figs. 1a, 1b, 1c, 1d.

As noted elsewhere the *Flabellum remondianum* of Vaughan is not the same as that of Gabb and is here renamed *F. stantoni* with Vaughan's figure 5 designated as the holotype. Vaughan has given an excellent description of it. Two poor specimens from the upper Santa Susana formation of the Simi Valley appear to belong to the same species although the lateral "wings" shown in Vaughan's figure 5 are not evident, but they were possibly lost by weathering.

Types.—Hypotypes nos. 30098, 30106.

Occurrence.—Loc. 7000, Santa Susana shale, Eocene, Santa Susana Quad., California. About 25 feet below basal conglomerate of Domengine stage in small canyon in center of sec. 32, T. 3 N., R. 17 W.; type locality, Army Point, near Benicia, California, horizon as "Martinez and Tejon" according to Vaughan.

Age.—Martinez (?) and Meganos stages.

FLABELLUM ? sp.
Plate 32, figure 5

A single poorly preserved specimen of a moderately large solitary coral; shape poorly cuneate, cross section ovate; base broken; largely decorticated; septa about 72, thin, earliest cycles most prominent; no pali evident.

Dimensions.—Height (broken) 12 mm., greatest diameter about 13 mm. (broken), least diameter 10.5 mm.

Types.—Hypotype Stanford Univ. Paleo. Type Coll. no. 6545.

Occurrence.—L.S.J.U. loc. 2073 (see *Deltocyathus whitei* for description), Lodo formation, Paleocene.

Remarks.—This specimen somewhat resembles *F. remondianum* Gabb, but is more ovate in cross section. It possibly is not a *Flabellum*, but no pali are apparent.

Genus PLATYTROCHUS Milne Edwards and Haime

Platytrochus MILNE EDWARDS and HAIME, *1848*, Ann. Sci. Nat., ser. 3, vol. 9, p. 246.

Genotype, *Turbinoliá stokesi* Lea.

PLATYTROCHUS DIABLOENSIS Durham, n. sp.

Plate 32, figures. 6, 7, 10, 11, 17

Corallum of medium small size, cuneiform to irregularly turbinate; septa in four cycles with corresponding costae; costae prominent, sharp, heavy, granulated, all extending to within a short distance of base; in cuneiform individuals middle costae of lateral faces heaviest near top of calyx, towards sides of more uniform size; end costae not accentuated; first three cycles of septa extending to rather large columella composed of irregularly fused septal trabeculae; septa of irregular thickness, in general first cycle heaviest, usually one-third to one-half the width of septal interspaces; septa more or less wavy, fairly abundant septal granules; character of upper edges of septa uncertain.

Dimensions.—Holotype, height 8.9 mm., greatest diameter 9 mm., least diameter 4.3 mm.

Types.—Holotype, no. 30060, paratypes nos. 30064, 30074, 30078, all from loc. A 3872.

Occurrence.—Loc. A 3821 (see *Cyclolites* ? n. sp. for locality description); loc. A 3872, Domengine stage, Eocene, Byron Quad., California, from *Discocylina* bed on brow of hill, east side of road, SE¼ NE¼ sec. 7, T. 1 S., R. 3 E., just above basal conglomerate.

Remarks.—Although several specimens were found at the type locality, none are exceptionally well preserved. One cross section strongly resembles the cross section of a *Turbinolia* although no *Turbinolia* of comparable size is known in that area. This specimen has not been considered in the above

description. The other specimens vary from nearly circular to elliptical in cross section. "*Flabellum?*" *merriami* Nomland is the only California species which might be confused with the cuneiform specimens; however it has well developed lateral wings near the base and every fourth costae larger and more prominent.

Genus DELTOCYATHUS Milne Edwards and Haime

Deltocyathus MILNE EDWARDS and HAIME, *1848*, Ann. Sci. Nat., ser. 3, vol. 9, p. 325.

Genotype, *Turbinolia italica* Michelotti.

DELTOCYATHUS WHITEI Durham, n. sp.
Plate 32, figures 13, 16; text figure 1

Corallum of medium size, discoid, traces of probable early attachment, upper surface partially concealed; lower surface nearly smooth, faint traces of low costae; costae fairly prominent on lateral edges of disc; septa in four cycles with rarely an incipient member of fifth cycle showing at wall, thin, wavy, exsert; first two cycles most exsert, later cycles less so; from trace of septal pattern exposed on lower side of corallum, first three cycles appear to reach columella while fourth extends about two-thirds of this distance; lateral faces of septa with moderate number of prominent granules, and growth lines forming prominent ridges, not perforate; edges of first and third cycles of septa with three teeth on inner half (text fig. 1), otherwise only occasionally faintly serrate; character of columella uncertain, obscured by matrix, composed of one or more irregular trabeculae.

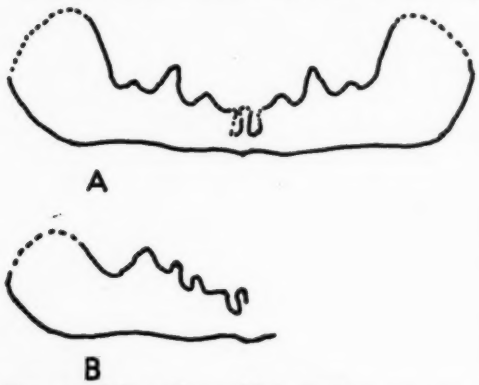


FIG. *1—Deltocyathus whitei* Durham, n. sp., ×2. Sketch profile of septa, in part restored from growth lines. Character of columella uncertain. *A*, first cycle; *B*, third cycle.

Dimensions.—Holotype, diameter 14 mm., height (restored) about 4.5 mm.

Types.—Holotype Stanford Univ. Paleo. Type Coll. no. 6546.

Occurrence.—L.S.J.U. loc. 2073, Panoche Quadrangle, California, 100 feet north of the middle of the south line of sec. 20, T. 15 S., R. 12 E., opposite the junction of Panoche and Silver Creeks. From Lodo formation exposed in road cut overlying Moreno shale. Age Paleocene. Collector Robert T. White.

Remarks.—There is no comparable described Pacific Coast species. *Stephanocyathus holcombensis* Durham from the lower Oligocene of Washington is much larger and has heavier septa that are not wavy.

Genus PLATYCYATHUS de Fromentel

Platycyathus DE FROMENTEL *1863*, Paleo. Franc., Terr. Cret., Zoophytes, p. 180.

Genotype, *Trochocyathus terquemi* Milne Edwards and Haime (subs. design. Wells, 1933).

PLATYCYATHUS GRAHAMI Durham, n. sp.
Plate 32, figures 12, 14

Corallum small, low, flattened bowl shaped, formerly attached to apex of small gastropod, base slightly convex; septa in four cycles, earlier cycles successively more exsert, but difference not very great; septa of first cycle about three times as heavy as those of fourth, other cycles intermediate; septa of fourth cycle extending about one-fourth distance to columella, third cycle slightly larger; upper edges of septa finely dentate, about four teeth in 1 mm.; lateral faces of septa with prominent granules; horizontal plates on sides of some septa, apparently formed in same manner as granules, not extending across cavity to next septa; pali before all cycles except last, those of third cycle wider than others; columella fascicular; distinct, rounded, granular costae on side walls, corresponding to septa.

Dimensions.—Holotype, height 4.2 mm., diameter 8 mm.

Types.—Holotype no. 30097.

Occurrence.—In grey clay shale float, probably from sediments of Martinez age.

From NW¼ sec. 8, T. 15 S., R. 12 E., Tierra Loma Quadrangle, California.

Remarks.—This species may be distinguished from *Trochocyathus californianus* Vaughan by its greater height, more regular shape, less abundant septal granules and rounded instead of sharp costae.

Genus CYCLOLITES Lamarck.

Cyclolites LAMARCK, *1801*, Syst. Anim. sans Vert., p. 369.

Genotype, *Cyclolites elliptica* Lamarck.

CYCLOLITES ? n. sp.
Plate 32, figure 9, text figure 2

Several molds of a vaulted, convex, disc shaped solitary coral; septa about 96, thin, highly perforate near wall, less so higher; lower surface concave downwards; faint traces of a small pedicel, costae corresponding to septa; no apparent traces of epitheca; wall apparently largely synapticular; synapticulae fairly abundant between septa above wall and between costae; about first two cycles of septa extend to columella, fifth cycle extending about one-third that distance, inner ends joined by synapticulae to those of second highest system adjacent to it; upper edges of septa uncertain but apparently dentate.

Dimensions.—Diameter about 15 mm., height about 5 mm.

Types.—Hypotypes nos. 30082, 30087, 30089.

Occurrence.—Loc. A 3821, Domengine stage, Eocene. On south side of low ridge, SE¼ SW¼ sec. 8, T. 1 S., R. 3 E., Byron Quadrangle, California. A short distance above basal conglomerate.

Remarks.—These specimens are associated with *Discocyclina* sp., *Spiroglyphus tinajasensis* Hana and Hertlein; *Platytrochus diabloensis* Durham, n. sp., and numerous molluscs.

FIG. 2—*Cyclolites?* n. sp, ×2. Sketch of lateral profile from mold in sandstone. Character of septal edges and presence or absence of columella uncertain.

Genus BALANOPHYLLIA Searles Wood

Balanophyllia SEARLES WOOD, *1844*, Ann. and Mag. Nat. Hist., vol. 13, p. 11.
Genotype: *Balanophyllia calyculus* Searles Wood.

BALANOPHYLLIA COWLITZENSIS
Durham, n. sp.
Plate 32, figures 15, 21

Corallum low, cylindrical, base greatly expanded, on shell of *Ranella washingtoniana* Weaver; wall porous, costae prominent, with single irregular row of heavy granules, corresponding to septa; costal interspaces perforate; septa in four cycles, possibly some of fifth present, in normal balanophylloid pattern, thin, not exsert, in broad open calyx; lateral faces of septa with few prominent granules; upper edges of septa indeterminate; columella small.

Dimensions.—Holotype, height about 2 mm., diameter of calix about 6 mm., diameter of basal expansion about 12 mm.

Types.—Holotype no. 30090.

Occurrence.—Loc. 7162, Cowlitz formation, upper Eocene. "Cowlitz lower shale, type locality" presumably on Stillwater Creek, in sec. 32, T. 11 N., R. 2 W., Lewis County, Washington, but possibly at the bend of the Cowlitz River in the SE¼ sec. 28, T. 11 N., R. 2 W.

Remarks.—This is readily separated from all previously described species of early Tertiary Pacific Coast *Balanophyllia* by its broad adherent base and short corallum.

Genus DENDROPHYLLIA de Blainville

Dendrophyllia DE BLAINVILLE, *1830*, Dict. des Sci. Nat., vol. 60, p. 319.
Genotype: *Madrepora ramea* Linnaeus.

DENDROPHYLLIA OLDROYDI Faustino?
Plate 32, figure 1

Dendrophyllia oldroydi FAUSTINO in OLDROYD, *1927*, Stanford Univ. Pub. Geol., Sci, vol. 1, no. 1, pl. 49, fig. 7.
Dendrophyllia oldroydi, FAUSTINO, *1931*, Philippine Jour. Sci., vol. 44, pp. 286–287, pl. 1, fig. 2.

Three worn fragments of a branching *Dendrophyllia* are inseparable from Faustino's species in their present state. The walls are thin near the calyx; the columella is moderately large and the septal arrangement appears to be the same.

Types.—Hypotypes nos. 30107, 30110, 30115.

Occurrence.—Loc. A 3770, late Pliocene or Pleistocene of Humboldt County, California. Exposed in road cut along U. S. highway 101, 1.5 miles north of bridge across Little River at Little River Beach State Park, from a highly fossiliferous gravel lense in loose sand.

Remarks.—This species is associated with a fauna that includes *Anorthoscutum* n. sp. (small), *Arca sisquocensis* Reinhart, var., and numerous undetermined mollusca, many of them being recent species. The exact age of the fauna is uncertain, it may be either late Pliocene or Pleistocene.

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A CONTRIBUTION FROM THE MUSEUM OF PALEONTOLOGY, UNIVERSITY OF CALIFORNIA. MANUSCRIPT RECEIVED BY THE EDITOR MARCH 5, 1942.

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 2, PP. 203–205, PL. 33, MARCH, 1943

PERMIAN FUSULINID FROM PERU

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ABSTRACT—*Schwagerina* aff. *S. laxissima* Dunbar and Skinner is described and illustrated from core samples of a well in central Peru. This form demonstrates the presence of Permian Wolfcamp in central Peru and represents one of the very few published records of Permian fusulinids from South America.

THREE limestone samples of cores taken from the discovery well of the Agua Caliente field, Department of Loreto, Peru, were sent to me from the Stanford University collections by Dr. H. G. Schenck. The highest of these samples is from a depth of 1,458 to 1,464 feet and contains abundant fusulinids that add considerable information to our knowledge of the geographic distribution of upper Paleozoic rocks in South America. The second of these samples is from a depth of 1,575 feet and contains abundant calcareous algae and a broken specimen of a large productid brachiopod. The lowest sample came from a depth of 3,128 feet and contains abundant calcareous algae and bryozoans. Although all of these samples are of interest, only the fusulinid-bearing sample will be discussed in detail at this time.

Abundant and varied fusulinid faunas are known from many areas in Brazil, Bolivia, Peru, and Venezuela. Only a very few forms have been described and illustrated from that portion of the world, however. Fusulinids have proved to be one of the most reliable indices for age determinations of upper Paleozoic rocks, and the occurrence of well preserved specimens of fusulinids in central Peru seems worthy of special consideration.

I wish to take this opportunity to express my sincere thanks to Professor Schenck for the opportunity to study this material and to Mr. Robert B. Moran for permission from the operators (Compañia de Petróleo Ganso Azul, Ltda., Caliente, Loreto, Peru) to publish this notice concerning these well samples of the Agua Caliente field.

Few studies have been published on South American fusulinids. In fact, for a long time it was believed by some that fusulinids did not occur south of the equator in any part of the world. Of the few published reports which have considered South American fusulinids, few if any of them give detailed information concerning the fusulinids sufficient for age determinations of the fusulinid-bearing rocks. The generic and specific affinities of no South American fusulinid can be determined with certainty from information so far published. One of the earliest records of fusulinids in South America was given by Katzer (1903). Katzer reported *Fusulina* from Itaituba, Para, Brazil. This form reported by Katzer has been neither described nor illustrated, and its generic affinities are not known.

In 1914 Meyer described and illustrated three fusulinids from Peru and Bolivia. One of these forms from near Morochata, Bolivia, was designated *Schellwienia convoluta* Meyer; a second form from Angostura de Yaco, Bolivia, was designated "*Schellwienia* aff. *vulgaris* Schellwien"; and a third form from near Tarma, Peru, was named *Schellwienia peruana* Meyer. As based on the general size and shape, septal fluting, and other general features shown by Meyer, the first two of these forms seem to be of Permian age. However, they were not described in sufficient detail for definite specific or generic identification, and their geologic ages are not definitely known. The third form, *Schellwienia peruana*, is minute in size. Its septa are essentially unfluted and its spirothecal structure is unknown, although the spirotheca was illustrated as thin. This form may be referable to either the genus *Fusulinella* or the genus *Triticites*. It suggests a Pennsylvanian age for rocks near Tarma, Peru.

Gerth (1915) listed several localities in southern Peru at which fusulinids were observed, but no information was given concerning the nature of the fusulinids themselves.

Steinmann (1929) gave considerable additional information concerning the geographic distribution of fusulinids in Peru and adds (p. 50)

Doch scheinen reine Fusulinenkalke von grösserer Mächtigkeit nicht allein in Perú, sondern auch in ganz Südamerika zu fehlen.

However, Steinmann did not give any detailed information concerning the nature of the Peruvian fusulinids.

In 1931 Gerth described and illustrated a fusulinid as "*Fusulina* cf. *verneuili* v. Möller" from Paso Palmarito in the southern part of Cordillere de Merida, Venezuela. Although specific affinities of this form can not be determined from Gerth's brief description and illustration, it is obviously of Permian age. It probably is referable to the genus *Schwagerina*, but it possibly is referable to the genus *Parafusulina*.

Berry (1933) described and illustrated three species of fusulinids from the Lake Titicaca area of Bolivia and Peru as *Fusulina peruana* (Meyer), *Fusulina berryi* (Jones), and *Fusulina prolongada* Berry. The details of wall structure and most other important characters of these forms can not be determined with certainty from Berry's descriptions and illustrations. The specimens referred to *F. peruana* by Berry probably are not conspecific with the types of that species but may be referable to the genus *Pseudoschwagerina*. The forms described as *F. berryi* and *F. prolongada* may be referable to the genus *Schwagerina*, to the genus *Parafusulina*, or even to the genus *Fusulina*. Their generic affinities can not be determined without a restudy of the original specimens.

In spite of this obvious abundance of fusulinids in various parts of South America, only the one report by Gerth of fusulinids from Venezuela gives us any undoubted information as to the stratigraphic age of the fusulinid-bearing strata. The information given by Gerth in this report, however, is definite enough only to demonstrate the almost certain occurrence of fusulinid-bearing rocks of Permian age in southern Venezuela.

The following description is based on a study of eleven sections of fusulinids from a core taken at a depth of 1,458 to 1,464 feet in the Wm. C. McDuffie No. 1 Agua Caliente well of the Agua Caliente field, Department of Loreto, Peru.

SCHWAGERINA aff. S. LAXISSIMA Dunbar and Skinner

Plate 33, figures 1–3

Schwagerina laxissima DUNBAR and SKINNER, *1937*, Univ. Texas Bull. 3701, pp. 652–654, pl. 68, figs. 1–11.

Although the specimens before me represent an undescribed species, it is not considered advisable to name a new species as based on well samples when such a small amount of material is available for study. I am, therefore, merely indicating the general resemblance of this Peruvian fusulinid to the form described by Dunbar and Skinner as *Schwagerina laxissima* from the Hueco limestone of extreme western Texas.

Shell large, elongate fusiform to subcylindrical; with bluntly pointed poles and low lateral slopes. Mature specimens contain about five volutions and measure about 12.0 mm. in length and 4.0 mm. in width. The majority of the thin sections I have are poorly oriented and therefore the form ratio of individual volutions is difficult to determine. However, one specimen gives the following values for the form ratio of the first to the fifth volution, respectively: 1:1.3, 1:1.8, 1:2.1, 1:3.1, and 1:3.0.

The proloculum is essentially spherical, and its inside diameter measures about 400 microns. The heights of the first to the fifth volution average about 140, 235, 425, 635, and 600 microns, respectively. As is shown by these figures, the inner two volutions are

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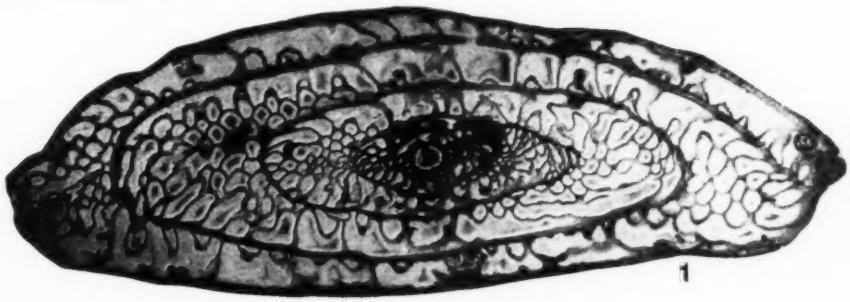
EXPLANATION OF PLATE 33

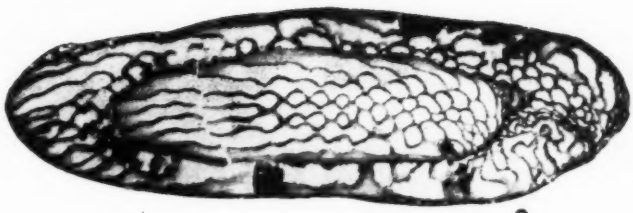
All original illustrations on this plate are unretouched photographs, and all illustrations are magnified ×10.

FIGS. *1–3*—*Schwagerina* aff. *S. laxissima* Dunbar and Skinner. *1*, Polished axial section; *2*, polished tangential section; and *3*, oblique thin section. Central Peru. (p. 204)

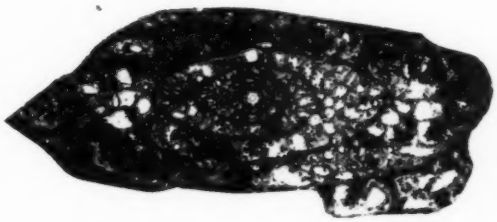
4—*Schwagerina laxissima* Dunbar and Skinner. Axial section of a syntype. Hueco limestone, Texas. (After Dunbar and Skinner).



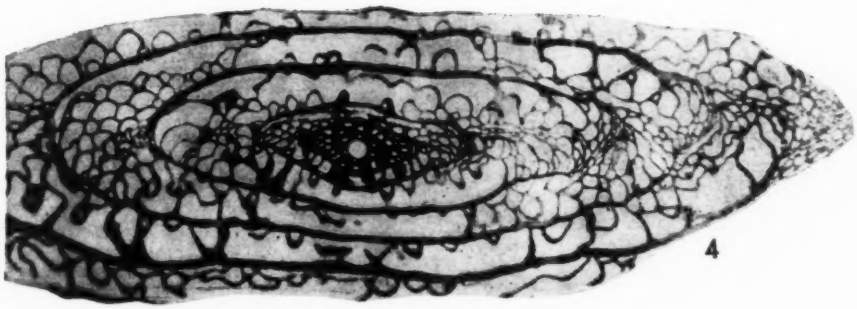
1



2



3



4

Thompson, Permian Fusulinid

UNIV. OF MICH.

relatively tightly coiled but the outer three volutions are inflated.

The spirotheca is thick and it is composed of a tectum and a keriotheca with coarse alveoli. The thickness of the spirotheca of the first to the fifth volution of a typical specimen measures about 30, 50, 80, 120, and 105 microns, respectively. The septa are thin. They are closely fluted in their lower two-thirds throughout the length of the shell, so as to form separate chamberlets. The upper third of the septa are broadly fluted, even up into the overlying spirotheca. As is shown in pl. 33, fig. 2, the fluting in the upper part of the chambers does not bring adjacent septa into contact. The septal count of the inner volutions was not determined, but one specimen has 30 septa in the fifth volution.

The tunnel is low and broad in the third and fourth volutions. The tunnel seems to be incompletely excavated in the outer portion of the shell. Neither chromata nor axial fillings have been observed in this form. However, the high degree of silicification of the specimens I have would almost certainly have destroyed any secondary deposits which were present before fossilization. The tunnel angle measures about 25 degrees in the third volution and 35 degrees in the fourth volution.

Discussion.—This species demonstrates beyond a reasonable doubt the occurrence of rocks of Permian age in the central part of Peru. The type specimens of *Schwagerina laxissima* were obtained from the upper portion of the Hueco limestone of extreme western Texas. The rate of expansion of the shell, size of the proloculum, size of corresponding volutions, number of volutions of mature specimens, and several other characters of the Peruvian specimens are not the same as in the types of *S. laxissima*. As is shown by a comparison of the illustration of the type specimen of *S. laxissima* here reproduced (pl. 33, fig. 4) and the accompanying illustrations of the form from Peru, these two fusulinids are biologically closely similar. They are probably closely related in age.

The Peruvian specimens here described are also closely similar to, and presumably closely related in age to, *Schwagerina alpina* (Schellwien) from the lower Permian of Europe and Asia. *S. alpina* and several closely related species of lower Permian age were recently referred by Rauser-Cernoussova (1937) to the genus *Rugosofusulina* Rauser-Cernoussova. It should be pointed out that almost all fusulinids from North America, Asia, and Europe, closely similar to the form here described from Peru, occur in strata that are all apparently equivalent in age to the type section of the American Permian Wolfcamp series.

Occurrence.—The specimens here described were obtained from a sample of a core taken at a depth of 1,458 to 1,464 feet in the Wm. C. McDuffie No. 1 well of the Agua Caliente field, Department of Loreto, Peru. This well is located about 3,400 meters west of the Aqua Caliente port on the Pachitea River. The Agua Caliente port is at Latitude 8°, 40′ 18.1″ South; Longitude 74° 41′ 04.9″ West.

Repository.—The specimens on which this study is largely based are deposited in the Stanford University Pal. Type Coll. no. 5970 (axial and tangential polished sections) and no. 5971 (oblique thin sections).

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JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 2, PP. 206–207, MARCH 1943

PALEONTOLOGICAL NOTES

HAPLOCYTHERIDEA BASSLERI STEPHENSON, NEW NAME FOR CYTHERIDEA SUBOVATA ULRICH AND BASSLER[1]

MORTON B. STEPHENSON
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Included in an ostracode fauna from the Miocene of Maryland was a species described as *Cytheridea subovata* Ulrich and Bassler (1904). The authors and subsequent workers apparently have failed to note the form described as *Cythere subovata* Münster (1830), which was later listed and figured by Roemer (1838) as *Cytherina subovata*, and still later described and figured by Egger (1858) as *Cytheridea subovata*.

The name *Cytheridea subovata* Ulrich and Bassler is thus a homonym of *Cytheridea subovata* (Münster). Doctor R. S. Bassler has suggested[2] that I propose a new name for the Maryland species. As it belongs to the genus *Haplocytheridea*, I therefore propose the new name *Haplocytheridea bassleri* Stephenson for *Cytheridea subovata* Ulrich and Bassler, not (Münster).

Originally described from the Calvert Miocene of Maryland, *Haplocytheridea bassleri* was later redescribed and figured by me (Stephenson, 1938) from the Miocene of Florida, and referred to by Howe and Hough (1935) in their description of *Anomocytheridea floridana* (Howe and Hough). I advised the authors of *Cytheridea subovata* Sutton and Williams (1939) that the name was preoccupied, and it was changed by them (1940) to *Haplocytheridea bastropensis*.

Mr. A. D. Ellis, Jr., assisted in checking the early references.

[1] Published with the permission of the Stanolind Oil and Gas Company.

[2] Personal communication.

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NUCULA TAMATAVICA ODHNER, NEW NAME FOR NUCULA RUGOSA ODHNER, 1919

NILS HJ. ODHNER
Riksmuseum, Stockholm, Sweden

Nucula rugosa Odhner, 1919 (not *Nucula rugosa* Buckland, nor *Nucula rugosa* Conti) was named and described (Arkiv. f. Zool., K. Svensk. Vetenskaps., vol. 12, pp. 23–24, pl. 2, figs. 15–18) for material from Tamatave, Madagascar, collected by M. W. Kaudern. This proves to be a homonym, as has been pointed out to me by Hubert G. Schenck of Stanford University, California. *Nucula rugosa* Buckland is a citation given by Bronn (Index Palaeontologicus, I. Abt., Zweite Hälfte, N-Z, p. 826, 1848), but I

have not seen the original in Buckland. L. Bellardi (Monografia delle Nuculidi trovate finora nei terreni terziari del Piemonte e della Liguria, Torino, pp. 12–13, 1875) pointed out under a description of *Nucula jeffreysi* that Conti, in 1864, named an Italian Pliocene species *Nucula rugosa*. The paper by Angelo Conti di Ferrara is reviewed by H. Crosse in the *Journal de Conchyliologie*, 3e ser., tome V (vol. 13), pp. 349–351, 1865, *Nucula rugosa*, p. 350. Therefore, a new name is here proposed: *Nucula tamatavica* Odhner, 1943, for the Recent species from Madagascar. The holotype is in the Naturhistoriska Riksmuseum, Evertebratavdelningen, Stockholm. Paratypes No. 6250, five specimens, are deposited in the Stanford University Paleontological Type Collection.

Subsequent to the original description of the species, Dautzenberg (Mollusques testacés marins de Madagascar, t. 3, p. 582, 1929) has recorded numerous Recent and Pleistocene occurrences of *Nucula rugosa* = *N. tamatavica*. Heath (Mém. Mus. Roy. Hist. Nat. Belgique, 2 sér., Fasc. 10, pp. 4, 7, 8, 9, 11, 16, 19, 24, pl. 2, figs. 11–14, pl. 3, fig. 23, pl. 8, fig. 69, pl. 10, fig. 84) has contributed to a knowledge of the soft parts. H. G. Schenck has an unpublished report in which he discusses this and allied species.

THE GULF FELLOWSHIP IN GEOLOGY

Announcement is made of the establishment by the Gulf Oil Corporation of a fellowship in geology at the University of Chicago. First award of the fellowship will be made for the school year 1943–44, provided qualified candidates are available under war conditions.

The fellowship stipend will approximate $1200 a year, the Gulf Corporation contributing $900 and the University making available additional funds or allowances equivalent to the tuition requirements, normally $300.

The initial award will be in the field of sedimentation and candidates must have had the equivalent of at least a year of graduate work in geology at an institution of recognized standing. The fellowship holder will be expected to devote part of his time to research in sedimentation. The fellowship may be renewed on recommendation of the Department. Renewal at the end of nine months, rather than at the end of a twelve-month period is possible if the fellow works under an accelerated program.

Application forms may be obtained from the Department of Geology, University of Chicago. The award for the 1943–44 school year will be announced April 1.

1943 VICTORY BOOK CAMPAIGN

Members of the Society of Economic Paleontologists and Mineralogists and members of the Paleontological Society are urged to contribute books for the enjoyment and education of those in our armed forces. Any interesting or informative book that is in good condition is desired. Technical books that are not too specialized will be welcomed. Books should be left at the nearest collection center or public library as soon as possible.

The 1943 Victory Book Campaign is sponsored by the American Library Association, The American Red Cross and the U. S. O.

JOURNAL OF PALEONTOLOGY, VOL. 17, NO. 2, PP. 208–211, MARCH 1943

REVIEWS

HADROSAURIAN DINOSAURS OF NORTH AMERICA, by Richard S. Lull and Nelda E. Wright, Aug. 31, 1942, pp. 242, 90 figs., 31 pls., 8 tables, Geol. Soc. America, Special Papers 40.

In the late Cretaceous there appears rather suddenly a curiously specialized and progressive group of dinosaurs, the duckbills or hadrosaurs. They are advanced over all other reptiles in having a complicated pavement of grinding teeth, doubtless for chewing vegetation. The beak, covered with horn, was supported in the lower jaw by a peculiar terminal predentary bone. The top of head was sometimes produced into a crest or hood which carried the narial canals, possibly to provide for breathing when the jaws were submerged during feeding. The tail was compressed and enlarged at the base to form a strong swimming organ. A network of ossified tendons stiffened and supported it, so, on land, the tail evidently counterbalanced the front of the body, permitting a bipedal posture with the small front limbs and feet free from the ground. The toes were blunt and hooflike, reduced in number, and enclosed in a mitten of thick skin on the front foot.

The hadrosaurs are most abundantly represented in paleontological collections in this country and in Canada. It was Marsh's intention to write a monograph on the predentate group, and the present work, along with previous memoirs on the ceratopsians, at last accomplishes that purpose.

This monograph, then, brings together descriptions of all the known North American hadrosaurs, and illustrates the better materials. It also deals with the detailed history of discovery of the fossils, and their geologic and geographic distribution. It interprets the physical environment, lists the associated plants and animals, identifies certain possible and probable food plants, discusses possible enemies and competitors and indicates means of defense and escape. The short evolutionary history of the group is outlined, and a really adequate treatment of the morphology is included. A review of characters of the integument is largely based on the famous dinosaur "mummies" and preserved skin impressions in several specimens. The treatment of locomotion and postures is illuminated by careful analyses of footprints, trackways, and impressions of the ventral parts of the body, as seen in the Triassic sandstones of the Connecticut Valley.

There is an interesting section devoted to the endocranial cast and an interpretation of the form of the brain and endosacrum; also one on the eye and ear. A more satisfactory and comprehensive survey could not be desired.

Under the heading "appendicular skeleton" are discussed the so-called sternal bones. These ossified elements occur in many dinosaurs and have been found in articulation with the calcified sternal ends of a few of the posterior ribs. They are always paired, never fused across the midline, and lie somewhat behind rather than above the coracoids. All this suggests that they represent the paired mesosternal bars sometimes found in crocodiles and lizards.

The authors discuss assumed differences in the postures of the uncrested and crested hadrosaurs, on evidence from the rigidity of the tail, the nature of the pelvis and acetabulum, and the Triassic ichnites. They conclude that:

> there is little difference in the bipedal posture of *Edmontosaurus* and *Corythosaurus* or in the quadrupedal pose, but when the seated position was attempted, with the knees and tarsal joint flexed and the body prone, the difference became at once distinct, and the function of the expanded ischial "foot" in the helmeted form seemed apparently to aid in supporting the rear of the body.

They argue that in all hadrosaurs:

> the thrust of the head of the femur must in every instance bear against the ilium, with its feebly developed pubic peduncle, and not against the comparatively light pubis which might well be dislocated by the stress of the animal's weight. This brings the ilium into a position more nearly horizontal than in certain notable mounted skeletons and this limits the erectness of the animal's posture, except possibly for very brief periods.

C. L. CAMP
University of California

GEOLOGY OF THE APPALACHIAN VALLEY IN VIRGINIA, by Charles Butts, Virginia Geological Survey, Bull. 52; Part I, Geological Text and Illustrations, pp. xxxiii and 568, 63 pls., 10 figs., 10 tables; Part II, Fossil Plates and Explanations, 271 pp., pls. 64–135; issued September, 1942: $1.50 complete, Part II separately, 50 cents.

The Appalachian Valley, extending for 400 miles along the western border of Virginia, is a classic region of folded and faulted mountains. The rocks range from Pre-Cambrian on the southeast to Carboniferous, forming a Paleozoic section averaging six miles of sediments of diverse characters and origins. The author devoted many years to a survey of this large area, first in the preparation of the geologic map (1933), subsequently in gathering more information for presentation in the present volumes. He profited from long experience with similar rocks in adjoining states, particularly in Alabama, which published a comparable state report in 1926. The new bulletin lays the foundation for future more detailed and specialized mapping and study. In this day of concentration on smaller units and areas, it is doubtful that geologists will become as familiar with the large region and greater sequence of Appalachian rocks as has the author. His hope that the report "will serve as a stepping stone for future detailed work" is bound to be realized; the earlier published map has been valued in the decade since its publication. Students of the Paleozoic rocks and structure of the Appalachian region will profit greatly from, and appreciate gratefully, the masterly fashion in which the author has prepared their paths.

The first part of the two-volume bulletin has an introductory chapter outlining the principal features of the Valley, and its regional setting. Through most of its pages, the volume is a summary of the more than sixty major units that have been most useful in the mapping, and the interpretation of the stratigraphy and structure. The nomenclature, definition, character, distribution, thickness, fauna and correlation of each is discussed. More than 100 sections, many describing several formations, and accompanying pictures of typical exposures, will serve to direct one to places where the beds can be seen to greatest advantage. Extended faunal lists add to the portrayal and will assist in identification and in correlation with other regions; in most cases the sources of the faunules are given. Succeeding pages describe and discuss the principal structures, having illustrations of representative sections and reproductions of photographs of critical localities. The range is from rocks that have been disturbed little to those that have been subjected to severe folding and have been intricately thrust; metamorphism rarely has destroyed the primary sedimentary features. The final pages summarize the history, interpreting the paleogeography on the basis of the preceding presentation.

The reviewer and others will differ from the author in his classification and correlation of the limited parts of the great sequence with which they are familiar, but the foundation on which revision is possible lies considerably in the maps and earlier publications that the author has presented. To this writer, for instance, it seems that the "Lenoir" and "Ottosee" as they are described are in part equivalent, and that most of the rocks discussed as Moccasin and "Lowville" are lowest Black River plus lower Trenton; others have found the Chambersburg to be a composite unit of Chazyan and Lower Trenton equivalents, and have reached different understanding of the "Stones River" units of western Virginia. In such an undertaking as this, too great emphasis on the details of stratigraphy would have defeated the larger purpose. That the units have been well chosen is evidenced in their producing the knowledge that has been gained of the distribution and structure of the rocks.

The second part of the bulletin comprises the finest summary of the stratigraphic paleontology of the Appalachian region that is available in a single volume. The book has 72 plates with nearly 2000 figures, and is particularly rich in illustrations of lower and middle Ordovician forms that are inadequately shown in present literature. There are a number of new species; it is regretted that their designations are inadequate and of doubtful validity, and that in many cases, type localities are insufficiently stated. The

fossils have been photographed admirably, this fine workmanship being credited to Charles Resser; the reproduction in fine-mesh half-tone on smooth paper is superb. The volume is a veritable handbook for those who study the rocks of the Appalachians or other eastern Paleozoic areas, a most useful complement to the stratigraphic descriptions. Both parts are nicely printed with very few errors of typography, and are a credit to the author, editor and Survey.

The *Geology of the Appalachian Valley in Virginia* becomes an indispensable bulletin in the library of those interested in Paleozoic stratigraphy and paleontology, and in the structure of the Appalachian system that served as the field in which some of the earliest interpretations of the character and origin of mountains developed. The book is appropriately dedicated to William Barton Rogers, a pioneer in the comprehension of the geology of the region.

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PLIOCENE VERTEBRATES FROM BIG SPRING CANYON, SOUTH DAKOTA, by Joseph T. Gregory, University of California Publications, Bulletin of the Department of Geological Sciences, 26, No. 4, pp. 307–446, 3 pls., 54 figs., July 31, 1942, $2.00.

Although this paper was written by one of the younger members in the field of vertebrate paleontology, it deserves special attention from all members of that profession as well as geologists who are interested in the stratigraphy of the high plains. This is one of the most complete faunal studies that has been published in recent years; complete in that the areal geology, sedimentation, correlation and literature are all included as well as the faunal study. Such an approach gives us a far more adequate picture of this fauna than does the usual faunal report. It reminds one of the earlier papers by Matthew on the White River section of northeastern Colorado. Here, as well as in the older paper, the geological considerations are as important as are those of the animals. Big Spring Canyon lies in the south central part of South Dakota, only a few miles north of the Nebraska line. Its fauna was discovered and described by Matthew and Gidley about 1905, and was considered as "Loup Fork" in age. Since that time it has been referred to by various writers but the question of its age and relationships was always somewhat uncertain. In 1933, 1934, and 1936, field parties of the University of California collected at this site and Mr. Gregory again visited the region in 1937.

The section in this area is of interest since it is between the extensive White River exposures to the northwest and the later Tertiary sections to the south and east. Unfortunately, the White River series does not outcrop near Big Spring Canyon, so the section here is not as complete as one would like. The name Arikaree is retained by Gregory for the Lower Miocene formations in this area. Although attempts have been made to discard this name on various grounds, the reviewer is strongly inclined to Mr. Gregory's view. The unconsolidated sands in Big Spring Canyon, from which the fauna was collected, are referred to the Ogallala group by the author. This is contrary to views expressed by the reviewer in another paper some years ago, but time has shown that the Ogallala is probably too extensive to be regarded as one formation and therefore must be looked upon as a group name. In the Big Spring Canyon section, Gregory demonstrates the presence of only two types of sediments, the flood plain sands in which fossils are rare, and the Channel sands in which the fossils are found. Both types of sediment are carefully discussed as to grain size, petrography and probable origin. The question of aeolian origin of some of the material is discussed on the basis of the work of Wentworth and Wanless, but it is concluded that the sediments are largely fresh water.

Big Spring Canyon contains the largest and most varied assemblage of Lower Pliocene genera to be found at any one locality. There are about 30 genera recorded from here. The distribution of the fossils was carefully recorded on a map as they were found and they were also accurately placed in the exposed section. The fauna is analyzed as to the distribution of the genera in time, and the late Lower Pliocene age is definitely shown. Outstanding in the collection is the camelid material, because of the

unquestionable association of limb bones and dentitions. The description of this material will be of great assistance in clearing up the confusion of the genera *Procamelus* and *Pliauchenia*. Throughout the faunal discussion Dr. Gregory is most conservative in his views, only three new forms are described. Wherever possible names already in print were used, and in the discussion of the horse material two of the older forms are thrown into synonymy.

Throughout, the paper is well illustrated and beautifully printed. One wishes there were more monographs of these typical faunas for reference. We use the name Clarendonian age for the Big Spring Canyon fauna, and yet we know a great deal less of the Clarendon fauna and its geologic background than we do of the Dakota locality.

Dr. Joseph T. Gregory has recently been called into the United States Army. Upon the termination of the present war, we hope Mr. Gregory returns to his duties at Ann Arbor to contribute more studies such as this one.

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GEOLOGICAL IMPORTANCE OF CALCAREOUS ALGAE WITH ANNOTATED BIBLIOGRAPHY, by J. Harlan Johnson, Quarterly of the Colorado School of Mines, vol. 38, no. 1, 102 pp., 23 figures, two tables; Golden, Colorado, Jan. 1943.

The bibliography of 935 items is of primary interest in this publication since only five pages are devoted to text and preface, and nine to figures illustrating various typical forms of calcareous algae. Geologists will find here many articles cited indicating the geologic importance of algae and their occurrences. Probably many of these references are not generally known. Nearly half of the entries are annotated, including many of the titles of special interest to students of calcareous algae. The annotations and four separate indices (subject, geographic, age, generic) make it easy to refer to literature on special topics, and of particular value to those having little previous acquaintance in the field.

The bibliography is admittedly incomplete; neither does it deal with calcareous algae exclusively. Older literature on boghead algae is cited but the more recent work of Thiessen, Zalessky and by Blackburn and Temperley, identifying these forms with *Botryococcus brauni*, has been omitted. Likewise several references are given to literature on *Parka*, but Don and Hickling's more thorough treatment is not listed. A few papers dealing with spores of higher plants (Zerndt 1930, Bailey 1935), and some others, are included for no very evident reason.

There probably are few who dispute the importance of algae as geologic agents in spite of the scant attention they usually receive. Johnson's bibliography will be of great assistance to anyone taking up investigation in this rather specialized branch of paleobotany, and both he and his associates at the Colorado School of Mines deserve praise for making it available. Possibly it may afford the needed impetus for initiation of studies by a larger number of workers.

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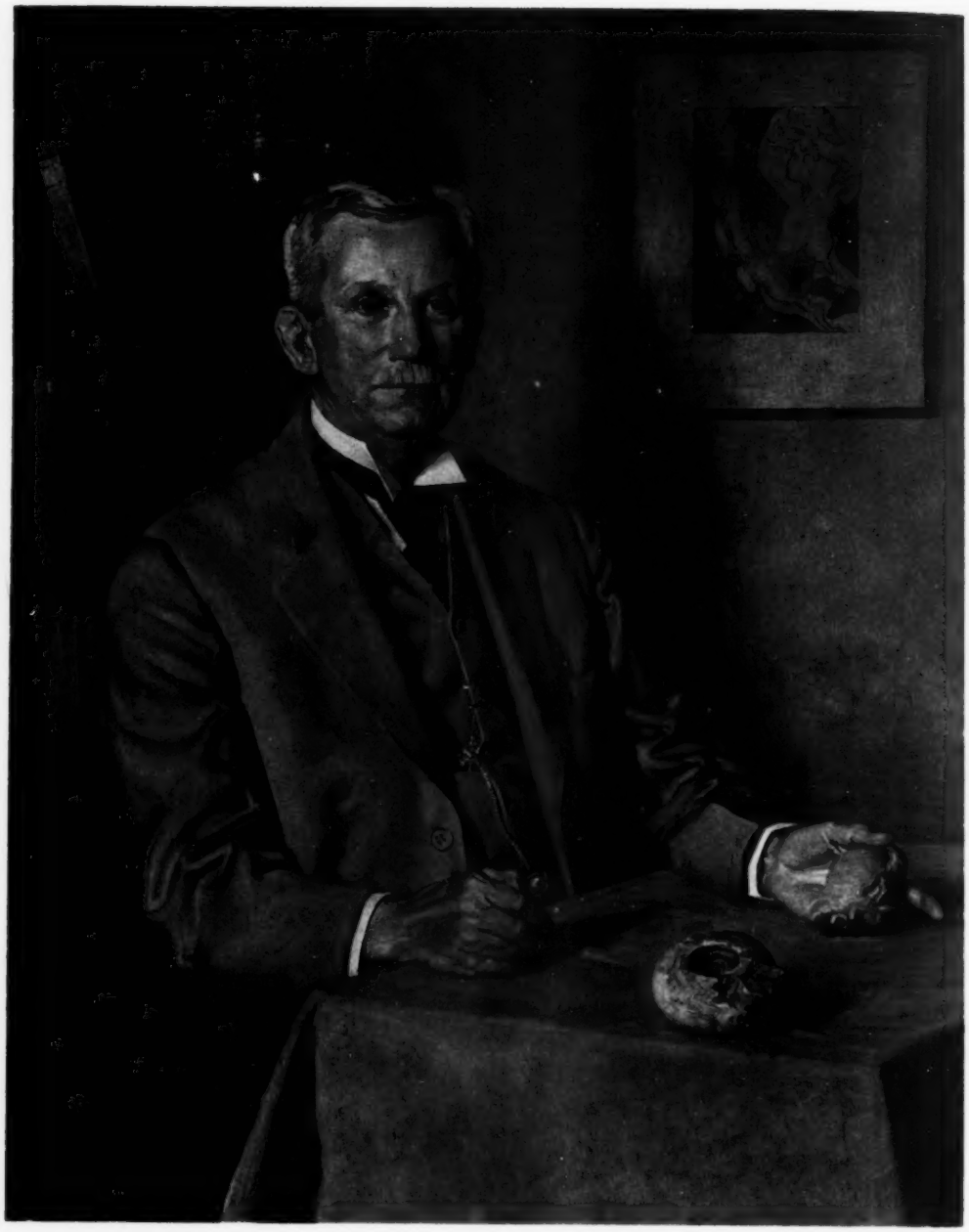

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